DRAFT
RESPONSE ACTION MEMORANDUM

East Kapolei II Pesticide Mixing and Loading Site
Ewa, Oahu, Hawaii
TMK (1) 9-1-017: Parcel 93 (Portion)

Prepared For:
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1.0 STATEMENT OF APPROVAL

1.1 Introduction

This Draft Response Action Memorandum (Draft RAM) documents and summarizes the proposed remedy for the East Kapolei II Pesticide Mixing and Loading (PML) site. The East Kapolei PML site consists of approximately 0.634-acres of land that is part of a larger 374.515-acre parcel owned by the Hawaii State Department of Hawaiian Home Lands (DHHL) and identified as TMK (1) 9-1-017: Parcel 93, Honouliuli, Ewa, Oahu, Hawaii. The site and surrounding areas were previously used for the commercial cultivation of sugarcane. The East Kapolei PML site, in particular, was used to mix and store pesticides for subsequent application in the field areas. Currently, the East Kapolei site is vacant and surrounding areas are leased for commercial cultivation of diversified fruit and vegetable crops.

This Draft RAM was prepared as a requirement under Section 11-451-15(h) of the State Contingency Plan for remedial actions. In addition, this Draft RAM satisfies Task 2.11 ("Prepare Draft Remedial Action Memorandum") in Attachment A: Scope of Work as described in the June 30, 2009 Agreement for Remedial Action between DHHL and the Hawaii State Department of Health (DOH).

This Draft RAM summarizes pertinent site information, provides a concise summary of environmental investigation data and the associated environmental hazards, documents the basis for remediation, and describes the rationale for selection of the preferred remedial alternative.

1.2 Assessment of the Property

Site investigation data indicate the presence of elevated arsenic, dioxins/furans (expressed as 2,3,7,8-tetrachlorodibenzo-p-dioxin [2,3,7,8-TCDD] Toxic Equivalents [TEQ]), pentachlorophenol, and triazine pesticides in soils throughout various areas within and adjacent to the East Kapolei PML site. An Environmental Hazard Evaluation (EHE) was prepared to assess the potential environmental hazards for the site and identify potential receptors and exposure pathways. The EHE identified direct exposure and leaching to groundwater hazards associated with contaminant concentrations in site soils. Receptors of concern included future site construction workers, future site users, future residents in surrounding areas, and aquatic ecological receptors.

The data suggests that hazardous substances existing on the East Kapolei PML site, if not appropriately addressed through implementation of the proposed response action, may present an endangerment to human health and the environment and could result in the migration of the contaminants.

1.3 Description of the Selected Remedy

The preferred remedial alternative for the site combines engineering controls (60-mil geomembrane liner and low permeability soil layers) with institutional controls to address contaminated soils on the site. Contaminated soil will be effectively isolated from direct human contact and the geomembrane liner will prevent downward migration of storm water through the contaminated soils, eliminating the primary mechanism for contaminant leaching from the soil. Institutional controls will include limits to the type of development atop and immediately surrounding the East Kapolei PML site, as well as long-term maintenance of the soil cover and vegetation. These controls would be identified and described in an Environmental Hazard Management Plan (EHMP) prepared for the site.

1.4 Declaration

The proposed remedial alternative has been judged by the DOH Hazard Evaluation and Emergency Response (HEER) Office to 1) be protective of human health and the environment; 2) comply with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action; and 3) be cost effective. The proposed remedy is in compliance with the Hawaii Environmental Response Law (Hawaii Revised Statutes 128D) and the Hawaii State Contingency Plan (Hawaii Administrative Rules 11-451).

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6-23-10
Date

2.0 SITE BACKGROUND

2.1 Site Description

The project site is the former Oahu Sugar Company pesticide mixing and loading area located near Kualakai Parkway approximately 1.2 miles east of Kapolei and 2.0 miles southwest of Waipahu. A map illustrating the site location is included as Figure 1 in Appendix I. The site was previously occupied by two abandoned buildings and several elevated aboveground storage tanks. These structures were recently demolished (December 2009) and documentation of site demolition activities is provided in the January 2010 *Demolition and Disposal Report, East Kapolei II, Former Pesticide Mixing and Loading Site, Ewa, Oahu, Hawaii* prepared by ETC on behalf of DHHL.

The East Kapolei PML site consists of approximately 0.634-acres that are part of a larger 374.515-acre parcel owned by DHHL and identified as TMK (1) 9-1-017: Parcel 93, Honouliuli, Ewa, Oahu, Hawaii (see Appendix I, Figure 2). The property is located within the State Urban District and is zoned by the City and County of Honolulu for agricultural use.

The East Kapolei PML site has no street address and is accessible via cane haul roads from Palehua Road, an unimproved roadway. The property is centrally located within agricultural fields that either remain fallow or are currently under short-term lease to agricultural tenants, primarily Aloun Farms, for commercial cultivation of fruit and vegetables. Existing uses in the vicinity of the property include the Ewa Villages Golf Course to the south, the West Loch Golf Course to the east, and city of Kapolei to the west. The nearest existing residences to the East Kapolei PML site are located in the Ewa Villages community and in the DHHL's "Kanehili" (East Kapolei I) development, situated approximately 0.7 miles southeast and 0.7 miles to the southwest, respectively.

The East Kapolei PML site is situated at an elevation of approximately 100 feet above mean sea level (msl) and the topography suggests a slight surface gradient to the south. No drinking water wells are located within one mile of the property, and the nearest surface water body is the West Loch of Pearl Harbor, located approximately 1.6 miles to the east.

The East Kapolei PML site was formerly characterized by abandoned, derelict buildings and several elevated storage tanks surrounded by a chain-link fence (see Appendix I, Figures 3 and 4). Ground cover within the fenced area consisted primarily of crushed coral covering native clay. A concrete-lined irrigation ditch runs adjacent to and through the fenced area. Prior to recently completed site sampling activities, all structures at the property were demolished. At the time of sample collection, ground cover consisted of bare soil with limited vegetation.

The East Kapolei PML site is not in use and is fenced off and locked. Warning signs are posted around the property. Outside of the fenced area, groundcover generally consists of loose native soil in the field areas, coral and cinder used as a base for the field roads, and concrete pads adjacent to the site gates.

2.2 Site Geology

The East Kapolei PML site is situated at an elevation of approximately 100 feet above msl. Soil at the property is classified by the U.S. Department of Agriculture (USDA) Soil Conservation Service as Honouliuli clay (HxA). The Honouliuli Series consists of well-drained soils on coastal plains in the Ewa area. These soils developed in alluvium derived from basic igneous rock. Honouliuli clay is dark reddish-brown, very sticky and very plastic clay, with 0 to 2 percent slopes underlain with coral reef limestone. Permeability is moderately slow, runoff is slow, and the erosion hazard is no more than slight. Workability is slightly difficult because of the very sticky and very plastic clay. The shrink-swell potential is high (USDA, 1972).

Observations made during previous subsurface investigations at the site indicated that existing site soils generally consist of a dark reddish-brown clay interspersed with relatively thin layers of coralline fill. Deeper soils exhibited a very plastic consistency, which impeded previous direct-push sampling efforts at greater depths, slowed hollow-stem auger drilling for monitoring well installation, and slowed groundwater recharge into boreholes. Recent investigations confirmed the geological descriptions above, with the exception of a larger fraction (and thicker layers) of coralline material in the near surface and shallow subsurface soils within the East Kapolei PML site boundaries.

2.3 Site Hydrogeology

According to Mink & Lau, 1990, the site is located above two aquifers within the Pearl Harbor Aquifer Sector, Waipahu Aquifer System. The upper aquifer is a basal, unconfined formation in sedimentary (nonvolcanic) lithology. Groundwater within this upper aquifer is a currently used, ecologically important, non-potable water source. This groundwater source is considered irreplaceable, with a low salinity and has a high vulnerability to contamination. The lower aquifer is a basal, confined aquifer in horizontally extensive lavas. The groundwater in this lower aquifer is a currently used, ecologically important, non-potable water source, and is further characterized as being an irreplaceable formation with a low salinity (between 250 and 1000 milligrams Cl^- per liter) and moderate vulnerability to contamination.

The depth to groundwater in the upper, unconfined aquifer in three monitoring wells previously installed within the site ranged from 79 to 85 feet below existing ground surface (approximately 15- to 20-feet above mean sea level). Data for older wells in the vicinity that apparently access the lower, confined aquifer indicate well depths of approximately 350- to 450-feet below mean sea level.

2.4 Historical Land Use

The East Kapolei PML site and surrounding lands were in sugarcane cultivation for over 100 years from approximately 1890 to 1994. Ewa Plantation Company operated the first sugar plantation in the area from 1890 to 1970, followed by Oahu Sugar Company, who leased the Project Site and surrounding lands from the Estate of James Campbell until 1994.

Ewa Plantation Company constructed the recently demolished buildings at the project site in 1953. The site was actively used for the storage, mixing, and loading of agricultural pesticides for approximately 40 years up to 1994. Pesticides were stored, mixed, and loaded onto trucks for distribution and dispersal in the plantation fields. In the 1950s, pentachlorophenol with diesel or kerosene was also mixed and applied. It is suspected that soils at the site became contaminated as a result of periodic chemical spills over the years. Such spills were typically not cleaned up by the plantation. Storm water runoff and truck movement from the site appear to have dispersed pesticides and contaminants outside the currently fenced area.

Activities on the East Kapolei PML site ceased when Oahu Sugar Company shut down operations in 1994. Through a condemnation proceeding, the State of Hawaii acquired the Project Site on August 22, 1994 by Land Court Document No. 2181717, recorded at the State of Hawaii Bureau of Conveyances on September 21, 1994. The site has not been utilized since plantation activities ceased.

2.5 Future Land Use

Following completion of remediation activities, DHHL proposes the redevelopment of the East Kapolei PML site and surrounding lands as part of the agency's "East Kapolei II" community. DHHL's master plan for "East Kapolei II" shows the site as located within a five-acre lot. No residential units will be located on the site itself, however, future land uses to be hosted at the site are contingent upon the selected methods of remediation.

2.6 Investigation History

A number of environmental investigations have been performed throughout the East Kapolei PML site and surrounding areas. Findings from these investigations indicated the presence of various pesticides and pesticide-related chemicals in site soils at elevated concentrations.

In general, data from these previous investigations have indicated that the East Kapolei PML site has been impacted by arsenic, dioxins/furans, pentachlorophenol, and triazine pesticides. Patterns within the data suggest that the areas beneath the former elevated ASTs, beneath a former mixing tank built into the patio of the office/storage structure, and behind the former boiler building (see Appendix I, Figures 3 and 4) contain the highest contaminant concentrations (identified as the "Spill Areas" of the site). The most recent March 2010 *Site Investigation Report and Environmental Hazard Evaluation* confirmed these patterns and also indicated the areas immediately adjacent to these Spill Areas (referred to as the "Investigation Areas" of the site) contained elevated concentrations of dioxins/furans and in certain instances, arsenic. The most recent data for samples collected from within the East Kapolei PML site boundaries were used to define both the magnitude and extent of contamination.

Historical investigations also suggest that there are contaminant impacts in soils outside of the existing East Kapolei PML site fence line. In particular, data obtained by ETC and documented in the August 2007 *Final Site Investigation and Preliminary Remedial Alternatives Analysis* indicate that dioxin impacts extend beyond the fence line, generally outside of the southwest gate, beyond decision units 8, 9, and 10 from the first "ring" of decision units, but limited to within the second "ring" of decision units. Similarly, discrete sample data collected by the US EPA in 2009 indicate that elevated arsenic concentrations exist in soil at depths of approximately 1 to 2 feet bgs in the same area and extending out to the south of the PML site, within the intersection of the coral/dirt roads. Finally, limited data collected by the DOH/EPA in the July 2000 *Site Inspection* indicate the presence of elevated dioxin TEQ concentrations in soil/sediment accumulated in the concrete-lined ditch adjacent to the East Kapolei PML site. Although the extent of dioxin impacts were not determined, DHHL and DOH decided that soil/sediment from sections of the concrete lined ditch located adjacent to and southwest (downgradient) of the East Kapolei PML site would be removed from the ditch during site remediation activities and addressed similar to other dioxin-impacted soil.

2.7 Magnitude and Extent of Contamination

Based on review of current and historic data, the extent of contaminants of concern (COC) impacts to soils at concentrations exceeding default DOH Environmental Action Levels (EALs) within and adjacent to the East Kapolei PML site is shown in Figures 7 through 11 in Appendix I.

In general, the highest dioxins/furans TEQ concentrations were identified in the surface soil within the Spill Areas (decision units SA1 through SA3), with decreasing concentrations in the Investigation Areas (decision units IAT1 through IAT5 and IA1 through IA4) and the lowest concentrations out beyond the fence line. The dioxins/furans TEQ concentrations also appeared to decrease with depth, however the concentrations within the 5- to 10-foot depth layers of the Spill Area still contained elevated concentrations (e.g., vertical delineation of dioxins/furans contamination has not been completed). Elevated dioxin concentrations were also identified in surface soils outside the southwest gate, but limited to within the second ring of decision units described in the August 2007 *Final Site Investigation and Preliminary Remedial Alternatives Analysis* report.

Arsenic concentrations were elevated within the Spill Areas, but concentrations generally decreased with depth and appeared to be limited to the top 2 feet of soil. Although elevated arsenic concentrations were not typically identified in the Investigation Areas, discrete sample data from outside of the fence line indicated elevated arsenic concentrations in the 1- to 2-foot layer of soil outside the southwest gate and within the intersection of the coral/dirt roadways.

Historic data indicated that elevated pentachlorophenol and triazine pesticide concentrations were generally limited to the Spill Areas of the East Kapolei PML site. Therefore, pentachlorophenol and triazine pesticides were only analyzed for soil samples within the Spill Areas. Data from the current investigation indicate that elevated concentrations were generally limited to the surface soil layer (with the exception of decision unit area SA3, where elevated pentachlorophenol concentrations were found within the 5- to 10-foot soil layer). However, uncertainty in the data measured by the calculated standard deviation (and thus the adjusted concentrations) requires that the assumption be made that pentachlorophenol and triazine pesticide contamination extend to 10 feet bgs.

Based on an overall evaluation of all available data compared to default DOH EALs, the following conclusions were made regarding the extent of contamination:

- Dioxin contamination exists within surface soils of all areas of the East Kapolei PML site (within the fence line) to depths of at least 10 feet bgs within the Spill Areas; to 5 feet in decision units IAT2, IAT4, and IAT5; to 2 feet bgs in decision units IAT1 and IAT3; and to 1 feet bgs in decision units IA1 through IA4. Discussions with DOH indicate that elevated contaminant concentrations located deeper than 10 feet bgs would constitute an incomplete direct exposure pathway since impacted soil would not be accessible to site users. However, the elevated COC may still trigger management requirements to ensure that the direct exposure pathway remains incomplete. It is also anticipated that dioxin contamination in soils outside of the fence line extend to a depth of 1 feet bgs and it is assumed that all soil and sediment in the concrete-lined ditch, from immediately adjacent to the PML site and downgradient (to Kualakai Parkway) is impacted with dioxins/furans at concentrations exceeding the default DOH EAL.

- Arsenic contamination exists in the top 2 feet of soil within the Spill Areas and within the top 2 feet of soil outside of the East Kapolei PML site fence line, within the coral/dirt roadways immediately adjacent to the southwest gate and within the roadway intersection.

- Pentachlorophenol and triazine pesticide contamination exists within the Spill Areas of the East Kapolei PML site down to 10 feet bgs.

The data indicate that while the lateral extent of contamination has been generally delineated, the vertical extent of contamination has not been delineated. Based on discussions with the DOH HEER Office, calculations of the total volume of soil impacted by COC will need to be estimated based on assumed depths through evaluation of the patterns in the data. Therefore, for the purposes of site remediation, the following areas and volumes of COC-impacted soil will need to be addressed.

2.7.1 Spill Areas

For the Spill Areas, total volume of impacted soil will be based on a depth of 10 feet bgs. Soil beneath 10 feet bgs is considered by the DOH to be unavailable for direct contact by surface receptors in unrestricted land use scenarios. Furthermore, the reported COC concentrations associated with leaching concerns at these depths were generally below their respective DOH EALs pertaining to soil leaching hazards. Total volumes of impacted soil in the Spill Areas with the associated environmental hazards are presented in Table 1, below.

Table 1: Impacted Soil Volumes, Spill Areas

Decision Unit	Depth Layer	Environmental Hazards	Total Volume (cy)
SA1	0’ – 0.5’	Direct exposure, leaching to groundwater	47
	0.5’ – 2’	Direct exposure, leaching to groundwater	142
	2’ – 5’	Direct exposure, leaching to groundwater	284
	5’ – 10’	Direct exposure, leaching to groundwater	474
SA2	0’ – 0.5’	Direct exposure, leaching to groundwater	31
	0.5’ – 2’	Direct exposure, leaching to groundwater	94
	2’ – 5’	Direct exposure, leaching to groundwater	183
	5’ – 10’	Direct exposure, leaching to groundwater	314
SA3	0’ – 0.5’	Direct exposure, leaching to groundwater	19
	0.5’ – 2’	Direct exposure, leaching to groundwater	58
	2’ – 5’	Direct exposure, leaching to groundwater	117
	5’ – 10’	Direct exposure, leaching to groundwater	194
		TOTAL	1,957

The total volume of soil impacted by COC in the Spill Areas is approximately 1,957 cubic yards (in-place, compacted). The environmental hazards associated with direct exposure and leaching to groundwater were identified for the entire volume. Dioxins/furans TEQ concentrations in the impacted soil from all decision units were well above the 1,000 ng/kg (1 part per billion) level.

Although terrestrial ecotoxicity hazards were initially identified to be associated with the elevated arsenic and pentachlorophenol concentrations, ETC does not believe that this hazard is considered significant. There are no known terrestrial ecological habitats in the immediate vicinity of the site and the East Kapolei PML site is currently and has historically been located in an area used for commercial agricultural operations. Anticipated future use does not include plans that would be conducive to terrestrial ecological habitats and/or use by endangered species. Furthermore, the primary concern is human direct exposure and remedies to address this hazard would also address terrestrial ecotoxicity concerns (since the ecotoxicity EALs for arsenic and pentachlorophenol are equal to or higher than the direct exposure EALs). Therefore, the terrestrial ecotoxicity hazard was removed from consideration for the Spill Areas.

2.7.2 Investigation Areas

For the Investigation Areas, total volume of impacted soil will be based on a depth of 5 feet bgs for decision units IAT1, IAT2, IAT4, and IAT5 (since dioxins and arsenic concentrations still exceeded their respective EALs at the 3-foot bgs depth limit of the trenches). For decision unit IAT3, the total volume of impacted soil will be based on a depth of 2 feet bgs (since COC concentrations in the 2- to 3-foot bgs layer were below default DOH EALs). For decision units IA1 to IA4, the total volume of impacted soil will be based on a depth of 2 feet bgs (since the dioxins concentrations in the 0- to 0.5-foot layer were close to the EAL and elevated concentrations are not anticipated to extend beyond the 2 foot depth). Total volumes of impacted soil in the Investigation Areas with the associated environmental hazards are presented in Table 2, below.

Table 2: Impacted Soil Volumes, Investigation Areas

Decision Unit	Depth Layer	Environmental Hazards	Total Volume (cy)
IA1	0 – 2'	Direct exposure	312
IA2	0 – 2'	Direct exposure	332
IA3	0 – 2'	Direct exposure	316
IA4	0 – 2'	Direct exposure	268
IAT1	0 – 0.5'	Direct exposure	87
	0.5' – 2'	Direct exposure	262
	2' – 3'	Direct exposure	174
	3' – 5'	Direct exposure	349
IAT2	0 – 0.5'	Direct exposure	90
	0.5' – 2'	Direct exposure	269
	2' – 3'	Direct exposure	180
	3' – 5'	Direct exposure	360
IAT3	0 – 0.5'	Direct exposure	53
	0.5' – 2'	Direct exposure	160
IAT4	0 – 0.5'	Direct exposure	56
	0.5' – 2'	Direct exposure	167
	2' – 3'	Direct exposure	112
	3' – 5'	Direct exposure	224
IAT5	0 – 0.5'	Direct exposure	46
	0.5' – 2'	Direct exposure	137
	2' – 3'	Direct exposure	92
	3' – 5'	Direct exposure	184
		TOTAL	4,230

The total volume of soil impacted by COC (mostly dioxins, with arsenic in IAT1) in the Investigation Areas is approximately 4,230 cubic yards (in-place, compacted). The environmental hazards associated with direct exposure was identified for the entire volume. Adjusted dioxins/furans TEQ concentrations were well above the 1,000 ng/kg level in all impacted soils, with the exception of soil in decision unit IAT1 at depths of 2- to 5-feet bgs (approximately 523 cubic yards with dioxins/furans TEQ concentrations between 450 ng/kg and 1,000 ng/kg). Arsenic impacts were only identified for soil from decision unit IAT1 at depths of 2- to 5-feet bgs.

As discussed in Section 2.7.1 above, the terrestrial ecotoxicity hazard was removed from consideration, since addressing the direct exposure hazard associated with arsenic in the Investigation Areas would also address the terrestrial ecotoxicity hazard.

2.7.3 Outside PML Site

For areas outside of the East Kapolei PML site fence line, direct exposure hazards associated with elevated dioxin and arsenic concentrations were identified.

Direct exposure hazards associated with dioxin impacts exist in an estimated 2 feet of soil located between the fence line of the PML site and the second ring of decision units described in the August 2007 *Final Site Investigation and Preliminary Remedial Alternatives Analysis* report. Direct exposure concerns (terrestrial ecotoxicity hazard removed from consideration, see Section 2.7.1) associated with arsenic impacts also exist in these general areas in an estimated 3 feet of soil, and extend further out into the intersection of the three coral/dirt roads. A total volume of dioxin and arsenic impacted soil is estimated at approximately 2,830 cubic yards (in-place, compacted, 1340 cubic yards dioxin impacts only, 1490 cubic yards dioxin and/or arsenic impacts). These areas are shown in Appendix I, Figures 7 and 8. Note that this volume also includes soil located between the East Kapolei PML site fence line and the coral road to the east. Based on the data, the dioxins/furans TEQ concentrations in these soils are anticipated between 450 ng/kg and 1,000 ng/kg.

Direct exposure hazards associated with dioxin impacts also exist in the soil/sediment contained within the portions of the concrete-lined ditch adjacent to and downgradient from the East Kapolei PML site. The estimated thickness of soil/sediment in the ditch is approximately 3 feet. The ditch is approximately 3- to 4-feet wide and the total length is approximately 800 feet. The total volume of dioxin impacted soil is estimated at approximately 311 cubic yards (not compacted). Based on data from the July 3, 2000 *Site Investigation*, the anticipated dioxins/furans TEQ concentrations exceed 1,000 ng/kg

3.0 ENVIRONMENTAL HAZARD EVALUATION

The Environmental Hazard Evaluation (EHE) process was developed by the Hawaii DOH to serve as a link between site investigation activities and the proposed response activities to be undertaken and evaluated in a Remedial Alternatives Analysis (RAA). The EHE is intended to identify potential environmental hazards associated with contaminant concentrations in site media through comparison with DOH EALs established for common environmental hazards. The March 2010 *Site Investigation Report and Environmental Hazard Evaluation* included a comparison of site data to DOH EALs for common environmental hazards associated with soil. These hazards included:

- Direct Exposure: exposure to contaminants via incidental ingestion, dermal absorption, and inhalation of vapors or dust in outdoor air
- Vapor Intrusion: emission of volatile contaminants from soil into overlying buildings
- Leaching: leaching of contamination from soil by infiltration of surface water (rainfall, irrigation, etc.) and downward migration of leachate into underlying groundwater
- Terrestrial ecotoxicity: toxicity to terrestrial flora and fauna
- Gross contamination: potentially mobile free product, odors, aesthetics, explosive hazards, and general resource degradation

3.1 Contaminants of Concern

Multiple lines of evidence, including data obtained from previous investigations at the site and descriptions of historic use, were used to identify the contaminants of concern (COC) for the East Kapolei PML site. The suspected sources of contamination at the East Kapolei PML site include the bulk storage, mixing, and distribution of pesticides and herbicides during sugarcane cultivation operations. Specifically, COC included:

- Arsenic (metal associated with historic pesticides);
- Polychlorinated dibenzo-dioxins/polychlorinated dibenzo-furans (dioxins/furans, associated with pentachlorophenol);
- Pentachlorophenol (chlorinated herbicide); and
- Triazine pesticides (specifically ametryn, atrazine, simazine, and trifluralin).

Note that other chlorinated herbicides and organochlorine pesticides were excluded from the COC list based on historical data. Pentachlorophenol and triazine pesticides were included based on elevated concentrations (i.e., exceeding appropriate action levels) in recent samples and based on their common usage in the Hawaii sugar industry. The presence of these COC at elevated concentrations, particularly in the "Spill Areas" (decision units SA1 through SA3, see Appendix I, Figure 6), was confirmed during the recently completed site investigation.

3.2 Exposure Setting

Preliminary evaluation of environmental hazards based on the historical data concluded that the primary environmental hazard posed by arsenic, dioxins/furans, and pentachlorophenol at the site is direct exposure threats to human health and that the primary environmental hazard posed by pentachlorophenol and triazine pesticides is leaching and potential impacts to groundwater (see "CSM Diagram – East Kapolei PML Site, Current Conditions" in Appendix I). Subsequent data obtained during the most recent site investigation confirmed the presence of these environmental hazards and identified the lateral extents of impact. Note that direct exposure hazards associated with pentachlorophenol and certain triazine pesticides (as well as pentachlorophenol, arsenic, and dioxins) were also identified in suspect "Spill Areas" at the PML site.

3.3 Receptors of Concern

When identifying potential receptors, plausible exposure under both current and future land-use was evaluated. Accordingly, potential receptors were identified for both current and future use scenarios. For the purposes of this project, the following potential receptors were identified.

Future Site Users

Current land use plans identify residential development surrounding the existing East Kapolei PML site. The use of the area encompassing and including the current East Kapolei PML site has not been identified. Exposure pathways for future site users include:

- Inhalation of particulates from surface soil
- Dermal contact with soil
- Incidental ingestion of soil

Future Residents in Surrounding Areas

Future residents of surrounding dwellings may be exposed to contaminants stemming from the East Kapolei PML site. Exposure pathways for future residents in surrounding areas include:

- Inhalation of fugitive dust from site soil
- Dermal contact with soil and sediment from surface water runoff
- Incidental ingestion of soil and sediment from surface water runoff

<u>*Site Construction Worker*</u>

The future land use scenarios could include the development of the site. As a result, the construction worker would be present during development. It is assumed that construction workers could be exposed to contaminated soil. Specifically, the exposure pathways for a construction worker include:

- Inhalation of fugitive dust from soil
- Dermal contact with soil
- Incidental ingestion of soil

<u>*Aquatic Ecological Receptors*</u>

Although remote due to the site's distance to the nearest surface water body, aquatic ecological habitats may be impacted by contaminants through sediment runoff and dissolved chemicals that may enter the groundwater (and subsequently migrate to surface waters).

3.4 Exposure Pathway Analysis

Exposure is defined as the contact of an organism with a chemical or physical agent. An exposure pathway is defined as "the course a chemical or physical agent takes from a source to an exposed organism." It describes "a unique mechanism by which an individual or population is exposed to chemicals or physical agents at or originating from a site (USEPA, 1989)." In order for an exposure pathway to be considered potentially complete, four elements must exist: 1) a source or release from a source; 2) a transport/exposure media; 3) an exposure point (point of contact with the contaminated medium); and 4) an exposure route. The potential exposure pathways present at the property are described below.

3.4.1 Soil Exposure Pathway

Direct contact with soil may result in incidental oral ingestion and/or dermal absorption of COC. Although generally associated with surface soil, direct contact may also occur with subsurface soil during trenching and excavation work.

3.4.2 Air Exposure Pathway

Air exposure pathways become potential routes of exposure when COC enter the air via volatilization or via adsorption to fugitive dust particles. Volatilization occurs when COC partition to the air. Such volatilization may occur from surface soil, subsurface soil, and/or groundwater. When considering volatilization from subsurface soil or groundwater, transport of COC occurs through void spaces in unsaturated soils, asphalt, and concrete to the outdoor air or to future indoor air through foundation cracks. For this site and under current conditions, volatilization is not considered to be a concern due to the semi- to non-volatile nature of the COC.

Generation of fugitive dust may occur through disturbance of affected soil, such as wind or construction activities. Dust particles may be inhaled, may settle on human skin and be ingested (hand to mouth), and/or may settle on vegetation that may be ingested by humans.

3.4.3 Sediment Exposure Pathway

Receptors may be exposed to COC in sediment from the property as a result of surface runoff during storm events to nearby drainageways, which may eventually discharge to the ocean. Sediment may accumulate in the marine environment and be available for contact with various receptors. Recreational users of the marine environment (swimmers, surfers, fishermen) may come into direct contact with sediment and be exposed through oral ingestion and/or dermal absorption. Ecological receptors may live directly in the impacted sediment and may be exposed to COC through feeding within the sediment. As a secondary transport mechanism, COC may accumulate in ecological receptors (i.e., fish, shellfish), then be ingested by human receptors.

3.4.4 Groundwater Exposure Pathway

Groundwater beneath the site may have been impacted by surface spills through leaching from impacted soils, particularly associated with triazine pesticides. Receptors may be exposed to COC in the groundwater by direct contact or by inhaling volatile COC emitted from the groundwater to air. For this site, direct contact with groundwater is not anticipated since the aquifer is not considered to be usable as a drinking water resource and the depth to groundwater (approximately 80 feet below ground surface) makes direct human contact very unlikely. Inhalation of volatile COC is not anticipated under current site conditions due to the semi- to non-volatile nature of the COC. Although direct exposure to groundwater at the property is unlikely, the potential exists for contaminants that may leach into the groundwater to migrate or be drawn into downgradient wells.

Ecological receptors may also be affected in shallow marine environments within groundwater discharge zones. This is the primary concern associated with the groundwater exposure pathway. However, based on existing data, groundwater beneath the site has not been impacted by COC.

3.5 Environmental Hazard Evaluation Summary

Data from the recent investigation was used to identify the extent and magnitude of existing environmental hazards within the fenced East Kapolei PML site. Historical data for areas outside of the East Kapolei PML site boundaries (i.e., outside of the fence line) were used to assess the lateral extent of COC impacts and identify existing environmental hazards. All DOH EALs used for comparison were based on unrestricted land use scenarios, based on reference documents that indicate groundwater beneath the site is not a current or potential drinking water source and the nearest surface water body is greater then 150 meters from the property.

A summary of the existing environmental hazards within the East Kapolei PML site is presented by decision unit in Table 3 below. These environmental hazards, as well as hazards outside of the East Kapolei PML site fence line, are shown in Appendix I, Figures 10 and 11.

Table 3: Summary of Environmental Hazards

Decision Unit	Type/ Depth	Layer Vol. (cy)	Direct Exposure	Terrestrial Ecotoxicity	Leaching to Groundwater
SA1.A	0-0.5’	47.4	Dioxins, As, PCP, ametryn, atrazine	As, PCP	PCP, ametryn, simazine
SA1.B	0.5'-2'	142.2	Dioxins, As, PCP, atrazine	As, PCP	PCP, ametryn
SA1.C	2'-5'	284.4	Dioxins, PCP, atrazine	PCP	PCP, ametryn
SA1.D	5'-10'	474.1	Dioxins, PCP, atrazine	PCP	PCP, ametryn
SA2.A	0-0.5’	31.4	Dioxins, As, PCP, ametryn, atrazine	As, PCP	Dioxins, PCP, ametryn, atrazine, simazine
SA2.B	0.5'-2'	94.2	Dioxins, As, PCP, atrazine	As, PCP	PCP, ametryn
SA2.C	2'-5'	183.3	Dioxins, PCP, atrazine	PCP	PCP, ametryn
SA2.D	5'-10'	313.9	Dioxins, PCP, atrazine	PCP	PCP, ametryn
SA3.A	0-0.5’	19.4	Dioxins, As, PCP, atrazine, simazine	As, PCP	Dioxins, PCP, ametryn, atrazine, simazine
SA3.B	0.5'-2'	58.3	Dioxins, PCP, atrazine	PCP	PCP, ametryn
SA3.C	2'-5'	116.7	Dioxins, PCP, atrazine	PCP	Dioxins, PCP, ametryn
SA3.D	5'-10'	194.4	Dioxins, PCP, atrazine	PCP	PCP, ametryn
IA1	0-0.5’	78	Dioxins		
IA2	0-0.5’	83	Dioxins		
IA3	0-0.5’	78.8	Dioxins		
IA4	0-0.5’	66.9	Dioxins		
IAT1.A	0-0.5’	87.2	Dioxins		
IAT1.B	0.5'-2'	261.7	Dioxins		
IAT1.C	2'-3'	174.4	As	As	
IAT2.A	0-0.5’	89.8	Dioxins		
IAT2.B	0.5'-2'	269.4	Dioxins		
IAT2.C	2'-3'	179.6	Dioxins		
IAT3.A	0-0.5’	53.4	Dioxins		
IAT3.B	0.5'-2'	160.3	Dioxins		
IAT3.C	2'-3'	106.9			
IAT4.A	0-0.5’	55.6	Dioxins		
IAT4.B	0.5'-2'	166.7	Dioxins		
IAT4.C	2'-3'	111.1	Dioxins		
IAT5.A	0-0.5’	45.6	Dioxins		
IAT5.B	0.5'-2'	136.7	Dioxins		
IAT5.C	2'-3'	91.1	Dioxins		

Outside of the East Kapolei PML site fence line, direct exposure and terrestrial ecotoxicity hazards associated with elevated arsenic concentrations exist in surface and near surface soil south and southwest of the PML, generally adjacent to the southwest gate and within the coral/dirt road intersection. Furthermore, direct exposure hazards associated with elevated dioxins/furans TEQ concentrations exist in surface soil southwest of the site out to the second decision unit ring identified in the August 2007 *Final Site Investigation and Preliminary Remedial Alternatives Analysis* report and within portions of the concrete-lined irrigation ditch adjacent to and southwest of the PML site. The estimated extent of direct exposure hazards and leaching to groundwater hazards are presented in Appendix I, Figures 10 and 11.

As previously discussed, although terrestrial ecotoxicity hazards were identified to be associated with the elevated arsenic and pentachlorophenol concentrations, this hazard was not considered to be significant. There are no known terrestrial ecological habitats in the immediate vicinity of the site and the East Kapolei PML site is currently and has historically been located in an area used for commercial agricultural operations. Anticipated future use does not include plans that would be conducive to terrestrial ecological habitats and/or use by endangered species. Furthermore, the primary concern is human direct exposure and remedies to address this hazard would also address terrestrial ecotoxicity concerns (since the ecotoxicity EALs for arsenic and pentachlorophenol are equal to or higher than the direct exposure EALs). Therefore, the terrestrial ecotoxicity hazard will no longer be considered for the Spill Areas.

4.0 REMEDIAL STRATEGY

The goal of the remedial strategy was to develop and select remedial alternatives that are effective and reliable in addressing the environmental hazards identified for the site based on the media of concern and the physio-chemical properties of the COC; and that can be implemented in a cost effective manner. The May 2010 *Remedial Alternatives Analysis Report* details the process used to determine the preferred remedial alternative, including the remedial action objectives, general response actions, potential response actions, response action screening criteria, and the development of remedial alternatives using the identified response actions.

4.1 Remedial Action Objectives

Remedial action objectives are specific goals to be achieved by the selected remedy. These objectives are specific to the anticipated exposure scenarios (based on current and future use of the site), site characteristics, COC, and potential outcomes. Remedial action objectives take into account compliance with threshold criteria, which are considered to be minimum requirements for any remedy considered for selection.

Based on the evaluation of both current and historic data, environmental hazards associated with the East Kapolei PML site include human direct exposure and leaching of COC to underlying groundwater. Therefore, the selected remedial action would need to sufficiently address these hazards. The following remedial action objectives were identified for this site:

- Reduce contaminant concentrations. This objective can be accomplished by removing the impacted media from the site or destroying the chemical composition of the contaminants through treatment.

- Remove direct exposure pathways between contaminants and receptors. This objective can be accomplished by removing or destroying the contaminants, changing the physical state of the contaminated media, or placing a barrier that would prevent direct contact between contaminants and receptors.

- Prevent migration of contaminants. This objective can be accomplished by removing or destroying the contaminants, changing the physical state of the contaminated media, or placing a barrier to immobilize contaminants.

- Minimize potential adverse impacts to the surrounding communities and the environment during implementation of the remedy.

- Meet applicable federal, state and local regulations pertaining to the site and the specific remedial action.

4.2 General Response Actions

Based on guidance in the DOH HEER Office TGM and to comply with Hawaii Administrative Rules §11-451-8, the following hierarchy of general response action alternatives was considered in order of descending preference:

- Reuse or recycling
- Destruction or detoxification of contaminants through alteration of their molecular structures and/or through neutralization
- Separation, concentration, or volume reduction
- Immobilization of hazardous substances through changing the physical state of the contaminant or contaminated media
- On-site or off-site disposal, isolation, or containment at an engineered facility designed to minimize the future release of hazardous substances, pollutants, or contaminants and in accordance with applicable regulations
- Institutional controls to restrict access and/or long-term monitoring to assess changes in contaminant distribution over time

Feasible response actions considered appropriate for addressing the contaminants at the site (sometimes referred to as presumptive remedies) were reviewed. These actions included destruction/detoxification of contaminants, chemical/physical fixation of contaminants, partial removal/relocation of contaminated soils, placement of a soil cover, implementation of engineering controls, and implementation of institutional controls.

4.3 Response Action Screening

The general response actions were used to develop a preliminary list of potential response actions that would satisfy the remedial objectives. Potential response actions were identified based on the media of concern (surface and subsurface soil), the physio-chemical properties of the contaminants of concern, and review of publicly available information regarding the effectiveness of these remedies at other sites with similar affected media and COC. The response actions were initially screened against three primary criteria to determine their suitability for use at the site. These criteria were 1) effectiveness; 2) implementability; and 3) estimated cost. Reuse or recycling as a general response action was removed from consideration based on the type and concentrations of contaminants encountered. The initial response actions were identified as follows:

1. No action
2. Destruction/detoxification (thermal desorption and in-situ vitrification technologies)
3. Chemical/physical fixation (in-situ vitrification technology)
4. Partial removal and relocation

5. Soil cover
6. Engineering controls
7. Institutional controls

4.4 Retained Response Actions

Retained response actions were determined based on their effectiveness in meeting remedial action objectives and through initial screening against the three primary criteria – effectiveness, implementability, and estimated cost. Six of the seven potential response actions were retained for further evaluation. A table summarizing the effectiveness of the retained response actions with respect to meeting the remedial action objectives is provided below.

Table 4: Effectiveness of Retained Response Actions

Response Action	Remedial Action Objectives				
	Reduce contaminant concentrations	**Remove exposure pathways**	**Prevent migration**	**Minimize adverse impacts**	**Meet applicable regulations**
No Action	-	-	-	-	-
Destruction/ Detoxification (Thermal desorption)	+/-	+/-	+	+/-	+/-
Partial Removal and Relocation	+	+	+	+/-	+
Soil Cover	-	+/-	+/-	+/-	-
Engineering Controls (Geomembrane liner)	-	+	+	+	+
Institutional Controls	-	+/-	-	+/-	-

\+ Remedial alternative achieves remedial action objective
+/- Remedial alternative partly achieves remedial action objective
\- Remedial alternative does not achieve remedial action objective

The in-situ vitrification technology (under both the destruction/detoxification and chemical/physical fixation response actions) was the only response action that was not retained from the original list. This response action, while having the potential to be technically viable, was removed due to issues associated with the feasibility of implementation. Multiple attempts were made to contact various contractors that reportedly had experience with this technology and no response was received. The lack of sufficient information for evaluating this process was the most significant reason for elimination. A less significant, but no less important consideration, was the estimated cost associated with implementation using unit costs developed by the U.S. EPA in 1997. These costs were considered to be high in relation to the costs of other remedial actions.

4.5 Development of Remedial Alternatives

Remedial alternatives were developed using the initial response actions described above. Combinations of response actions were considered to address weaknesses associated with the effectiveness of individual response actions. The five remedial alternatives developed for the East Kapolei PML site are summarized below:

- Remedial Alternative 1: No action. The no action alternative requires that no specific activity be performed to address the existing COC-impacted soil at the East Kapolei PML site. Over time, certain COC (specifically pentachlorophenol and triazine pesticides) will naturally attenuate. This alternative will not be effective in removing exposure pathways, preventing migration of COC, and/or minimizing either short-term or long-term impacts to the surrounding communities. Furthermore, this remedial alternative would not be administratively feasible since it is unlikely that approvals will be obtained from the appropriate regulatory agencies or by members of the community. This remedial alternative was retained as the default alternative for the purpose of evaluating other alternatives. This would be the least aggressive remedial alternative.

- Remedial Alternative 2: Geomembrane liner cover system. This alternative would incorporate engineering controls to isolate contaminated soil coupled with institutional controls to ensure that contaminated soil beneath the liner system remain undisturbed. Engineering controls would include the placement of a 60-mil HDPE liner over areas where leaching to groundwater environmental hazards were identified and placement of compacted layers of clean soil over remaining areas where direct exposure environmental hazards were identified. Institutional controls would include the placement of a visual indicator or barrier above the contaminated soil, placement of a metallic barrier tape grid that can be detected from the finish ground surface using electromagnetic instrumentation, and land use restrictions to avoid disturbance of the capped soil. Impacted soil located outside of the existing East Kapolei PML site fence line would be excavated and moved into the site boundaries prior to placement of the cap system. This would be a moderately aggressive remedial alternative.

- Remedial Alternative 3: Limited excavation and placement of soil cover. This alternative would incorporate partial removal and relocation of contaminated soil with the soil cover and institutional controls response actions. Existing soil within the East Kapolei PML site would be excavated to depths of 10 feet below ground surface (bgs) within the Spill Areas of the site and the excavated soil would be transported to an appropriate treatment or disposal facility that can accept the dioxins/furans concentrations existing in the soil. Thereafter, impacted soil located outside of the existing East Kapolei PML site fence line would be relocated back onto the PML site and a soil cover would be placed above the impacted soil. Institutional controls, such as placement of the visual indicator or barrier above contaminated soil, placement of the metallic tape grid, and land use restrictions, would then be implemented to ensure that residual contaminated soil beneath the soil cover remain undisturbed. This alternative would be considered an aggressive approach to site remediation.

- Remedial Alternative 4: Thermal desorption and placement of soil cover. This alternative would incorporate the destruction/detoxicification of contaminated soil using thermal desorption technology, coupled with the soil cover and institutional controls response actions. The thermal desorption process would be used to reduce the concentrations of organic compounds (dioxins/furans, pentachlorophenol, and triazine herbicides) and the soil cover would be used to prevent direct exposure to the remaining inorganic compounds (arsenic). Institutional controls, such as placement of the visual indicator or barrier above contaminated soil, placement of the metallic tape grid, and land use restrictions, would then be implemented to ensure that residual contaminated soil beneath the soil cover remain undisturbed. This alternative would be considered an aggressive approach to site remediation.

- Remedial Alternative 5: Excavation and off-site treatment/disposal. This alternative would entail the removal and relocation of the majority of contaminated soil from the East Kapolei PML site and surrounding areas. The excavated soil would be transported to an appropriate treatment or disposal facility that can accept the dioxins/furans concentrations existing in the soil. Where possible, particularly soil located in areas outside of the PML site fence line (see Appendix I, Figure 10), soil with lower levels of dioxins/furans will be transported to a local landfill for disposal. Thereafter, institutional controls, such as placement of the visual indicator or barrier above contaminated soil, placement of the metallic tape grid, and land use restrictions, would be implemented to ensure that residual contaminated soil in the subsurface beneath the backfill material remain undisturbed. This would be considered the most aggressive remedial alternative.

These remedial alternatives were described in detail in the May 2010 *Remedial Alternatives Analysis Report*.

5.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

A comparative analysis of the remedial alternatives was performed based on evaluation of detailed criteria. These criteria included evaluations of a remedy's effectiveness, implementability, and overall cost. This section describes the comparison of the remedial alternatives against one another based on the detailed criteria.

5.1 Overall Protection of Human Health and the Environment

This criterion is a subcategory of the effectiveness criterion. Generally, all remedial alternatives would need to satisfy this criterion to some degree in order to be considered for implementation.

Comparative analysis indicates that Alternative 5 would rate the highest in satisfying this criterion since the majority of COC-impacted soils would be removed from the site. Alternative 2 would rate as the next best option since multiple barriers would be placed between the environmental hazards and potential receptors, and controls would be in place to mitigate the existing soil leaching hazard. Alternatives 3 and 4 would rank lower than Alternative 2. Although the soil leaching hazard would be mitigated through either excavation or treatment, these remedies do not completely remove the direct exposure hazards. Alternative 1 would be the least effective remedy since the neither direct exposure nor soil leaching hazards would be addressed.

5.2 Compliance with ARARs

This criterion is a subcategory of the effectiveness criterion. Typically, remedial alternatives would need to satisfy ARARs common to a specific site and these ARARs are usually associated with the criterion above – overall protection of human health and the environment. However, certain remedial alternatives would trigger additional ARARs, depending upon the methods used. For example, if a remedial alternative requires transportation of contaminated soils on public highways, this would trigger a set of ARARs associated with U.S. Department of Transportation regulations pertaining to transport of hazardous materials. Other remedial alternatives that do not require such measures would not trigger these ARARs.

Comparative analysis indicates that Alternative 2 would rate the highest in satisfying this criterion since there would be only a limited number of ARARs applicable to this alternative, such as County permits pertaining to grading and stockpiling, in addition to satisfaction of the primary ARARs associated with protection of human health and the environment. Alternative 3 would rate as the next best option. Although there would be significant handling of impacted soil, as well as transporting soil on public highways and across navigable waters, the quantity of soil is significantly less than the quantity of soil targeted for removal in Alternative 5. Alternative 4 was rated lower than Alternative 3 due to the ARARs associated with air emissions during thermal treatment, in addition to ARARs associated relocating soils outside of the fence line back onto the East Kapolei PML site. Alternative 5 would trigger a multitude of ARARs due to the volume of soil being handled and the transportation requirements, as well as solid waste regulations associated with any local landfill disposal. Alternative 1 would rate the lowest since it would not comply with the primary ARARs associated with protection of human health and the environment.

5.3 Reduction of Toxicity, Mobility, and Volume

This criterion is another subcategory of the effectiveness criterion. Certain remedial alternatives are able to be protective of human health and the environment and meet ARARs through the reduction of contaminant toxicity, mobility, and/or volume to some degree.

Comparative analysis indicates that Alternative 5 would rate the highest in satisfying this criterion since the majority of contaminated soil would be removed from the project site. Alternative 4 would rate as the next best option since the thermal desorption process volatilizes the bulk of the organic contaminants to concentrations below ARARs and the waste product (generated by capturing the vapor and treating the vapor) would be disposed off-site, leaving only the inorganic contaminant, arsenic. Alternative 3 would rate lower than Alternative 4 since limited removal of contaminated soil would still result in a large contaminant mass left at the project site, however data suggest that the remaining contaminant mass would not be mobile at the site based on detected concentrations. Alternative 2 would be rated second to last since this alternative does not reduce the toxicity or volume of contaminated soil, but it does provide controls to prevent contaminant mobility in the subsurface. Alternative 1 would be the least desirable remedy in this category since there would be no measures to reduce the toxicity and/or volume of contaminated soil and there would be no controls to prevent the downward migration of contaminants through storm water infiltration.

5.4 Long-Term Effectiveness

This criterion is another subcategory of the effectiveness criterion and refers to how well a remedial alternative will perform in mitigating the environmental hazards at the site over the long-term.

Comparative analysis indicates that Alternative 5 would rate the highest in satisfying this criterion since the bulk of contaminated soil would be removed from the project site. Alternative 2 would rate as the next best option in this category based on the predicted lifespan of the geomembrane liner material (estimated in industry studies at approximately 200 years for buried applications) and the difficulties associated with breaching both the soil cap and the geomembrane liner. Although the difficulties in breaching a soil cover would be similar for both Alternatives 3 and 4, Alternative 4 would rate as the next best option pertaining to long-term effectiveness since the bulk of the organic contaminants would have been volatilized through the thermal desorption process, with only arsenic remaining in site soils. Alternative 3 would rate next, then Alternative 1 would be rated last since the no action alternative is not a reliable method for addressing contaminants at the site over the long-term.

5.5 Short-Term Effects

This is the last subcategory in the effectiveness criterion. Short-term effects refer to the potential environmental impacts the remedial alternative may have on surrounding human populations, ecological populations, and ecological habitats. This also includes the length of time required for full implementation of the remedial alternative since typically, the longer it takes to implement a remedy, the higher the potential for environmental impacts to receptors. The preference would be for a remedial alternative to have the least short-term impacts to surrounding populations and lands.

Comparative analysis indicates that Alternative 1 would rate the highest in this category since leaving the contaminated soil undisturbed while placing the clean fill required for site development over the contaminated soil would create the least opportunity for short-term environmental impacts. The next best option for meeting this criterion would be Alternative 2, since placement of the geomembrane liner and associated soil cap would not require excessive soil disturbance (other than relocating contaminated soil located outside of the East Kapolei PML site into the fenced boundaries) during implementation. Furthermore, the implementation time for this alternative would be relatively short in comparison to all but Alternative 1. Alternative 4 would be rated as the next best option since handling of contaminated soil would be relegated to the areas within and surrounding the East Kapolei PML site only, and would not extend into areas with high human populations. However, the timeframes required for full implementation of this remedy and the requirement for capturing and handling the by-product of this remedy (contaminant vapors, concentrated waste streams of liquids and filter material, etc.) would be a significant concern. Alternative 3 would be rated as the less desirable remedy due to the potential for significant short-term impacts during excavation, packaging, transportation, and treatment/disposal of the contaminated soils. Although this alternative would likely require a significantly shorter time frame to implement as compared to Alternative 4, the opportunities for environmental impacts are more numerous with transport of contaminated soil on public highways and through navigable waters. Finally, Alternative 5 would be rated last in this category since the potential environmental impacts associated with excavation, packaging, transportation, and treatment/disposal of the contaminated soils would have the highest short-term impacts to surrounding populations/lands and would be exacerbated (as compared to Alternative 3) based on the total overall volume of soil that would need to be handled.

5.6 Technical Feasibility

This criterion is a subcategory of the implementability criterion and refers to the compatibility of the alternative with site conditions and the ease of obtaining the appropriate equipment, facilities, and specialists needed to implement the remedy.

Comparative analysis indicates that Alternative 1 would be the most technically feasible alternative since it would require no specialized equipment and would be compatible with site conditions. The next best option to meet this criterion would be Alternative 2. Although specialized materials, equipment, and personnel would be needed to construct the geomembrane liner cover system, such activities have been performed in Hawaii for numerous applications. Alternative 3 would be rated as the next best option that meets this criterion. Although the transportation and off-site treatment/disposal of the contaminated soil would be difficult to coordinate due to the location of the anticipated disposal facility (located on the east coast of Canada), the excavation/packaging portion of the remedy and the placement of the soil cap would be relatively simple. Alternative 5 would be very similar to Alternative 3, however it receives a lower rating based on the increased volume of contaminated soil that needs to be handled. Alternative 4 would be the lowest rated remedy since there has been no pilot-scale testing under actual site conditions to determine the efficiency of the thermal desorption treatment process on the volatilization of dioxins/furans. Furthermore, there are significant logistical concerns associated with obtaining the appropriate power requirements to provide the desired heat settings.

5.7 Administrative Feasibility

This criterion is also a subcategory of the implementability criterion and refers to the availability of the necessary approvals to implement the remedy and anticipated degree of the community's acceptance of the remedy.

Comparative analysis indicates that Alternative 5 would likely rate the highest in this category since this remedy would provide the most reliable long-term solution for addressing contaminants at the site. The potential drawbacks to this remedy considered problematic were the community acceptance of transporting contaminated soils to a local landfill, the potential short-term impacts associated with transportation of the contaminated soil on public highways and navigable waters, and the overall coordination of transporting the contaminated soil to the appropriate treatment/disposal facilities. The next best option in this category would be Alternative 2 since the community as a whole would recognize that, although the toxicity or volume of contaminated soil would not be reduced, this remedy would effectively provide multiple barriers (geomembrane liner and soil cap) between surface receptors and the existing contaminants. Furthermore, this type of remedy has been implemented at various locations within the State for other applications, including the encapsulation of former landfills. Alternative 4 would rate the next highest since organic contaminants would be volatilized during the thermal desorption process and the soil cap would provide a barrier between surface receptors and the remaining inorganic contaminant, arsenic. Alternative 4 was rated below Alternative 2 mainly because of the anticipated approvals required to generate/transfer the appropriate electricity requirements to drive the thermal desorption process and the approvals required to discharge liquids and vapors generated during the thermal desorption process. Alternative 4 rated higher than Alternative 3 since a higher contaminant mass would be removed from the site (i.e., volatilization of organic contaminants) in comparison. Alternative 3 would be the next option based on this criterion since it would remove soil with the highest contaminant concentrations from the site and provide a barrier, in the form of a soil cap, between surface receptors and the residual contaminants in the site soils. Finally, Alternative 1 would be rated last since it is anticipated that there would likely be very little community support for the no action alternative and the DOH is unlikely to provide adequate approval for this no action remedy.

5.8 Estimated Costs

This criterion refers to the overall costs associated with a remedial alternative. The overall costs include both capital costs for initial implementation of the remedy and on-going operations and maintenance costs required to ensure the effectiveness of the remedy. Typically, costs weigh heavily in the remedial alternative selection process, since costs have a significant impact on the planned future use of a site.

Specific to this project, the overall costs for implementation of a remedial alternative takes on even more significance for the community as a whole in the State. The DHHL's primary mission is "To manage the Hawaiian Home Lands trust effectively and to develop and deliver lands to native Hawaiians." Prudent use of trust funds is crucial to the DHHL's operations and its ability to fulfill its mission in providing lands to native Hawaiian beneficiaries. As such, the selection of a high-cost remedial alternative would be detrimental to DHHL's ability to complete current, planned developments and/or may limit the scope of future developments, potentially resulting in a lower percentage of beneficiaries receiving land and housing. Therefore, evaluation of the remedial alternatives for the East Kapolei PML site must consider the direct effects on the site itself, as well as the effects on any currently planned and/or future development projects.

A summary of the costs are presented in Table 5 below. Note that costs associated with placement of the soil cap were not included since such activities would be incorporated within site development costs. The exception to this would be for Alternative 2, the geomembrane liner cover system, since there are specific requirements for soil cap placement. In addition, the costs associated with relocating contaminated soil from outside of the East Kapolei PML site fence line were considered common to Alternatives 2 through 4 and therefore were built into the estimates. The waste management costs for Alternatives 3 and 5 are highly dependent upon whether a specific facility on the continental U.S. is able and willing to accept soil with elevated dioxin TEQ concentrations. Although the farmers' exemption would be applicable and therefore the soil would not be considered a RCRA hazardous waste (assuming waste profile sample data indicate TCLP concentrations below toxicity threshold values), disposal facilities may not be willing to accept the soil due to the high dioxin TEQ and potential liability that may be associated with such concentrations. Finally, ongoing operations and maintenance costs for all remedial alternatives were considered to be low and highly dependent upon the ultimate future use of the property.

Table 5: Comparison of Estimated Costs

Description	Alternative				
	1	2	3	4	5
Project Management/QC	-	$165,000	$123,000	$441,000	$479,000
Site Preparation	-	$450,000	$305,000	$1,132,000	$130,000
Implementation of Remedy	-	$1,010,000	$835,000	$4,007,000	$2,820,000
Utility Requirements	-	-	-	$1,315,000	-
Waste Management	-	-	$800,000 to $4,050,000	$60,000	$3,245,000 to $13,225,000
Documentation/Reporting	-	$70,000	$100,000	$195,000	$139,000
Estimated Total Capital Costs	$0	$1,695,000	$2,163,000 to $5,413,000	$7,150,000	$6,813,000 to $16,793,000
Estimated Annual O&M Costs	-	$15,000	$10,000	$10,000	$10,000

Project Management/QC – includes planning, design, permitting, construction management, and QA/QC
Site Preparation – includes mobilization and relocation of soil outside of fence line back onto the site
Waste Management – includes transportation and disposal of any wastes generated
Documentation/Reporting – includes anticipated sampling and reporting requirements
Estimated Annual O&M – estimated costs associated with maintaining engineering or institutional controls per year

5.9 Summary of Comparative Analysis of Remedial Alternatives

The comparative analysis of remedial alternatives with respect to the screening criteria is summarized using numerical values in Table 6 below. The alternative with the highest ranking for a specific criterion was given a score of 5 and the alternative with the lowest ranking for a specific criterion was given a score of 1. Therefore, the alternative with the highest composite numerical value would rank the highest in this scoring system. It should be noted that the rankings were based on an "equal-weight" scoring system, where all criteria were considered to be of equal importance. Oftentimes, this is not the case, particularly in situations where funding is limited or in the presence of other constraints.

Table 6: Ranking of Remedial Alternatives

Criteria	Alternative				
	1	2	3	4	5
Effectiveness: Overall protection of human health & the environment	1	4	3.5	3.5	5
Effectiveness: Compliance with ARARs	1	5	4	3	2
Effectiveness: Reduction of toxicity, mobility, and volume	1	2	3	4	5
Effectiveness: Long-term effectiveness	1	4	2	3	5
Effectiveness: Short-term effects	5	4	2	3	1
Implementability: Technical feasibility	5	4	3	1	2
Implementability: Administrative feasibility	1	4	2	3	5
Overall Costs	5	4	3	2	1
Composite Score	20	31	22.5	22.5	26

5.9.1 Alternative 1: No Action

Alternative 1 ranked last in comparison to the other four alternatives with a composite score of 20. The no action alternative was considered to be the least effective in protecting human health and the environment; complying with ARARs; reducing the toxicity, mobility, and volume of contaminants; and in its long-term reliability. It was also considered to be the alternative least likely to receive the appropriate approvals and community support. However, this alternative did rank highest since it is anticipated to have the least amount of short-term effects associated with its implementation, the ease of implementation, and the projected overall costs.

5.9.2 Alternative 2: Geomembrane Liner Cover System

Alternative 2 ranked first in comparison to the other four alternatives with a composite score of 31. This alternative would adequately comply with ARARs and was considered to be sufficiently protective of human health and the environment since it would isolate the environmental hazards associated with the existing contaminants beneath an impermeable geomembrane barrier and beneath a soil cap. This alternative is a proven and reliable long-term solution that has been implemented in many applications, including use in isolating waste from surface water infiltration and from direct contact with surface receptors. The short-term effects of this alternative would be minimal and primarily due to moving contaminated soil located outside of the fenced boundary back within the East Kapolei PML site (a common activity between three of the five alternatives). Furthermore, since this technology has been implemented before in the State of Hawaii, it was considered to be both technically and administratively feasible. Finally, the estimated cost to implement this remedial alternative was significantly lower than all but the no action alternative. The primary drawback of this alternative is that it does not reduce the toxicity or volume of contaminated soil, it just isolates the soil from surface receptor exposure and minimizes the mobility of the existing contaminants by preventing contact between surface water infiltration and the contaminants.

5.9.3 Alternative 3: Limited Excavation and Placement of Soil Cover

Alternative 3 was ranked third (same composite score as Alternative 4) out of the five remedial alternatives under consideration with a composite score of 22.5. This alternative would adequately comply with ARARs and was considered to be sufficiently protective of human health and the environment since it would remove the environmental hazard associated with contaminant leaching from the soil and include a barrier between direct exposure hazards in the soil and surface receptors. The primary concerns with respect to these criteria were the remaining contaminants (both organic and inorganic) in the soil. This alternative would reduce the volume of contaminated soil through removal of soil with the highest contaminant concentrations. Ratings for long-term effectiveness and short-term effects during implementation of this remedy were relatively low due to the potential for degradation of the soil cover and the potential hazards associated with handling and management of contaminated soils during excavation and transportation. Although implementation of this remedial alternative would be somewhat complicated due to coordination of waste transportation and with the appropriate off-site treatment/disposal facility, it would not be considered insurmountable. However, community acceptance of this alternative is anticipated to be relatively low. Finally, the range of costs for this remedial alternative could be significantly higher in comparison to a higher ranked alternative (e.g., Alternative 2).

5.9.4 Alternative 4: Thermal Desorption and Placement of Soil Cover

Alternative 4 ranked third (same composite score as Alternative 3) out of the five remedial alternatives under consideration with a composite score of 22.5. As with Alternatives 2 and 3, this alternative would adequately comply with ARARs and was considered to be sufficiently protective of human health and the environment since it would theoretically volatilize all organic contaminants to concentrations below DOH EALs and would include a barrier between the direct exposure hazards associated with the residual arsenic (inorganic contaminant) and surface receptors. The primary concerns with respect to these criteria were the remaining arsenic contaminated soil. This alternative would provide a significant reduction in contaminated soil toxicity and volume, and would result in minimizing the mobility of arsenic contaminated soils (i.e., minimize dust generation and surface runoff). This alternative's rating for long-term effectiveness was higher than Alternatives 2 and 3 since, theoretically, a larger reduction in contaminant volume would be achieved. Although there were concerns associated with capturing liquid and vapor-phase byproducts of the thermal desorption process, short-term effects were considered to be less than Alternatives 3 and 5 since there would be little waste being transported on public highways and navigable waters. The technical feasibility of this remedial alternative was considered the lowest of the five alternatives since the only data showing the effectiveness of the thermal desorption process was obtained through testing in a controlled, laboratory setting. It is unknown how well the thermal desorption process would perform under site-specific conditions and there are concerns regarding the infrastructure requirements for transferring sufficient electricity over a prolonged period of time to the site. Furthermore, this alternative would need to comply with a separate set of ARARs associated with air emissions and obtained the appropriate air emissions permits is anticipated to be a lengthy process that may influence the overall time frames associated with implementing this remedy. In addition, specialized equipment and personnel with specialized experience in implementing this remedy would need to be brought in to the state. This would likely require a significant coordination effort and was anticipated to be a potential concern. From the administrative feasibility standpoint, this alternative was anticipated to receive adequate community support and obtaining approvals to conduct the work would be lengthy but achievable. Finally, the estimated costs ranked next to last due to the high costs associated with implementation of the remedy.

5.9.5 Alternative 5: Excavation and Off-Site Treatment/Disposal

Alternative 5 ranked second out of the five alternatives under consideration with a composite score of 26. This remedial alternative ranked the highest in three of the five effectiveness criteria. This remedy would provide the most protection of human health and the environment, would provide the greatest reduction in contaminant toxicity and volume at the site, and was considered to be the most effective method for addressing the contaminants over the long term. Although this alternative received a lower ranking for compliance with ARARs, the ranking was associated with the number of additional ARARs that this remedial alternative would trigger (in comparison to other alternatives) rather than the ability of this method to meet the primary ARARs associated with protection of human health and the environment. This remedial alternative was also anticipated to garner the highest support in the community in the immediate vicinity of the site. The primary drawbacks of this alternative were the potential short-term effects associated with the large volumes of soil that would need to handled at the site (potential for fugitive dust emissions and contaminated surface runoff), and transported across public highways and navigable waterways, and the excessive costs associated with the implementation of this remedy. A less significant drawback is the technical feasibility of obtaining approvals from a local landfill for acceptance of a portion of the contaminated soil volume and the coordination required to transport such large volumes of contaminated soil to a treatment/disposal facility outside of the state.

6.0 PROPOSED REMEDY

Based on the comparative analysis of remedial alternatives using the specified screening criteria, the preferred remedial alternative to address environmental hazards at the East Kapolei PML site is Alternative 2 – Geomembrane Liner Cover System.

6.1 Remedy Description

The geomembrane liner cover system (GLCS) alternative would utilize engineering controls and institutional controls to address the environmental hazards identified at the East Kapolei PML site. Engineering controls would include subgrade preparation, a geotextile protection layer, a 60-mil HDPE (or equivalent) geomembrane layer, a compacted soil cover layer, and a top soil layer with vegetation. Institutional controls would include the placement of a metallic barrier tape layer that would be detected by future surface toning, placement of a visual barrier (such as orange construction fencing) over contaminated soil to warn against disturbing the contaminated soil, recording of land use restrictions with the property deed and/or a uniform environmental covenant, as well as preparation and implementation of an EHMP to manage the contaminated soil in-place.

Prior to system installation, off-site areas of contamination (i.e., areas located outside of the East Kapolei PML site fence line as shown in Appendix I, Figure 10) would be excavated and transported to the site. Residual contaminant levels would be verified in these excavations by way of multi increment confirmation samples. Clean fill material would then be utilized to replace the excavated off-site material.

The COC-impacted soils relocated onto the site would then be graded and compacted to provide a relatively firm and even surface. Thereafter, the visual barrier would be placed over the contaminated soil. Clean, low permeability soil would then be imported onto the site; placed on top of the visual barrier and over the Spill Areas (areas where leaching to groundwater environmental hazards were identified), and compacted to form an approximate 24-inch thick layer. This layer would provide the uniformly firm and smooth surface needed to minimize/prevent differential settlement and potential damage to the HDPE liner. A layer of non-woven geotextile fabric would then be installed immediately above the subgrade.

The 60-mil geomembrane liner would then be placed above the geotextile fabric. Liner seams will need to be welded by personnel with experience in these types of installation and the contractor installing the liner will need to perform its own quality control. To ensure proper installation, independent quality assurance checks should be performed by experienced and knowledgeable personnel. Care should be taken to minimize the liner's solar exposure to minimize material degradation.

Following installation of the liner, similar low-permeability soil would be placed and compacted in the remaining areas of the site (i.e., Investigation Areas) to match the elevation of the area covered with the liner. A metallic barrier tape grid would then be placed across the filled areas of the East Kapolei PML site. The grid of metallic tape can be detected using geophysical means (i.e., when toning to identify underground utility lines prior to excavation) and will serve as a mechanism to warn of the contaminated soil. Upon completion of the barrier tape grid layout, a low-permeability soil cover layer would be placed and compacted to an approximate

24-inch thickness. It is suggested that this layer be constructed of the same material as the subgrade. A 6-inch layer of top soil would be placed above the 24-inch soil cover layer. The top soil should be seeded or vegetated following placement, but the final ground cover would be dependent upon future land use plans. This cap system will isolate soils with contaminant concentrations that exceed field area background levels due to historic pesticide mixing/loading operations from potential human receptors.

The layering system described above would create multiple barriers between contaminated soils and potential receptors, therefore mitigating the direct exposure hazard associated with contaminant concentrations in site soils. The 60-mil HDPE (or equivalent) liner would provide the primary barrier against storm water infiltration through the contaminated soil, therefore preventing migration of contaminants via soil leaching. The visual barrier and the metallic barrier tape grid would provide a warning system to minimize the potential for future disturbance of the contaminated soils. A conceptual cross section drawing of the liner system is presented in Appendix I, Figure 12 and a conceptual plan view drawing of the geomembrane liner cover system is presented in Appendix I, Figure 13.

Various geomembrane industry sources have suggested that, with good periodic maintenance practices, the life expectancy of a HDPE geomembrane liner in buried applications can be up to 200 years. After completion, the GLCS and soil cap should be inspected on a quarterly basis to detect damage, stress, or any other detrimental conditions. Some routine operation and maintenance (O&M) work would include the following:

- removal of large vegetation or trees that may penetrate the soil cover;
- correction of water-ponding conditions;
- repair of cracks on soil cover to prevent potential solar exposure of the geomembrane layer; and
- repair of any eroded areas after storm events.

6.2 Benefits and Drawbacks

The primary benefits of the GLCS alternative include the following:

- Adequately addresses the two environmental hazards identified at the site – human direct exposure and contaminant leaching from soil – through use of engineering controls and institutional controls.
- Provides reliable, long-term protection of overall human health by isolating soils with contaminant concentrations that exceed field area background levels due to historic pesticide mixing/loading operations from human contact.
- The 60-mil HDPE (or equivalent) liner will prevent infiltration of surface water through the pesticide-contaminated soil, therefore minimizing and/or eliminating the potential generation of contaminated leachate that may migrate to the underlying groundwater.

- Minimal potential for migration of contaminants during implementation (e.g., no vapors generated, minimal soil handling, no transportation of wastes off-site).
- The visual indicator barrier and the metallic barrier tape grid will provide a physical warning system to minimize the potential for disturbance of contaminated soil through future excavation work.
- Implementation of the remedy is well understood since this type of installation has been performed for other sites within the State for various purposes, including the encapsulation and isolation of waste.
- Cost of implementation is anticipated to be relatively low, therefore the remedy would have a lesser effect on DHHL's operations and other projects/programs funded using the Hawaiian Home Lands trust funds as compared to other remedial alternatives.
- Cost savings during site development may be realized since less soil would need to be imported to fill the site (e.g., no soil removal planned as part of the remedy).

The primary drawbacks of this remedial alternative include the following:

- This alternative will not reduce the toxicity or volume of the contaminants, it will only isolate and immobilize the contaminated media. Natural degradation of certain contaminants may occur over time, however arsenic and dioxins/furans concentrations are anticipated to remain constant.
- Specialized equipment, material, and personnel will be needed to implement this remedy.
- Institutional controls will need to be put into place to avoid damage to the geomembrane liner cover system and prevent disturbance of the underlying contaminated soil.
- There will be limitations on future land development directly atop the geomembrane liner.
- Regular monitoring of the surface soil layers and the vegetation will be needed, as well as maintenance of the soil and vegetation to avoid compromising the geomembrane liner.

6.3 Environmental Hazard Evaluation – Post Implementation

The data obtained from historic investigation activities and the more recent site investigation identified direct exposure and leaching as the two significant environmental hazards associated with existing conditions at the site. An appropriate remedial alternative would need to address both these existing hazards in order to be considered an effective and viable solution to protect human health and the environment. The remaining three hazards (vapor intrusion, gross contamination, and terrestrial ecotoxicity) were considered to be insignificant in comparison and/or would be mitigated if direct exposure and leaching hazards were addressed.

The preferred GLCS remedial alternative would address both direct exposure and leaching hazards through the use of engineering and institutional controls. Placement of the compacted soil sub-base, 60-mil HDPE (or equivalent) geomembrane liner, the compacted soil layer above the liner, and vegetated topsoil layer (or other type of groundcover, which may include asphalt or concrete pavement, etc.) would provide an effective mechanism to break exposure pathways between anticipated receptors of concern (future site users, future residents in surrounding areas, future site construction workers, and aquatic ecological receptors) and the COC-impacted soil. The physical presence of the soil layers and the geomembrane liner will prevent direct exposure to human receptors and the presence of the impermeable geomembrane liner will mitigate concerns associated with surface water infiltration through the COC-impacted soil and the creation of contaminated leachate that may migrate to the underlying groundwater. The presence of the visual indicator barrier and the metallic barrier tape grid would provide a physical warning system to indicate the presence of the contaminated soil and to minimize/prevent the occurrence of contaminated soil disturbance through future excavation activities. A Conceptual Site Model diagram depicting the conditions at the site after implementation of the preferred alternative has been included in Appendix I ("CSM Diagram – East Kapolei PML Site, Site Conditions after Implementation of Preferred Alternative").

In order to maintain the integrity of the engineering controls, institutional controls would need to be implemented to avoid re-establishment of exposure pathways. Therefore, institutional controls would need to include, at a minimum:

- Limitations on the future land use maintained in perpetuity (such as a Uniform Environmental Covenant that gets filed with the property deed) to avoid activities that may compromise the integrity of the engineering controls (e.g., excavation or drilling through the soil cap and geomembrane liner).

- Placement of a metallic barrier tape grid that would be evident to electromagnetic or ground penetrating radar instrumentation typically used prior to excavation activities to identify subsurface anomalies (e.g., underground utility lines).

- Placement of a visual indicator barrier to warn against further excavation into contaminated soils.

- Preparation and implementation of an Environmental Hazard Management Plan to describe, at a minimum, appropriate cap maintenance/reporting requirements, prohibited activities that may compromise the integrity of the engineering controls, appropriate soil handling and worker/area protection requirements should disturbance of the contaminated soils be unavoidable, and appropriate mitigation measures if a portion of the soil cap and/or geomembrane liner is breached.

7.0 REFERENCES

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APPENDIX I

FIGURES

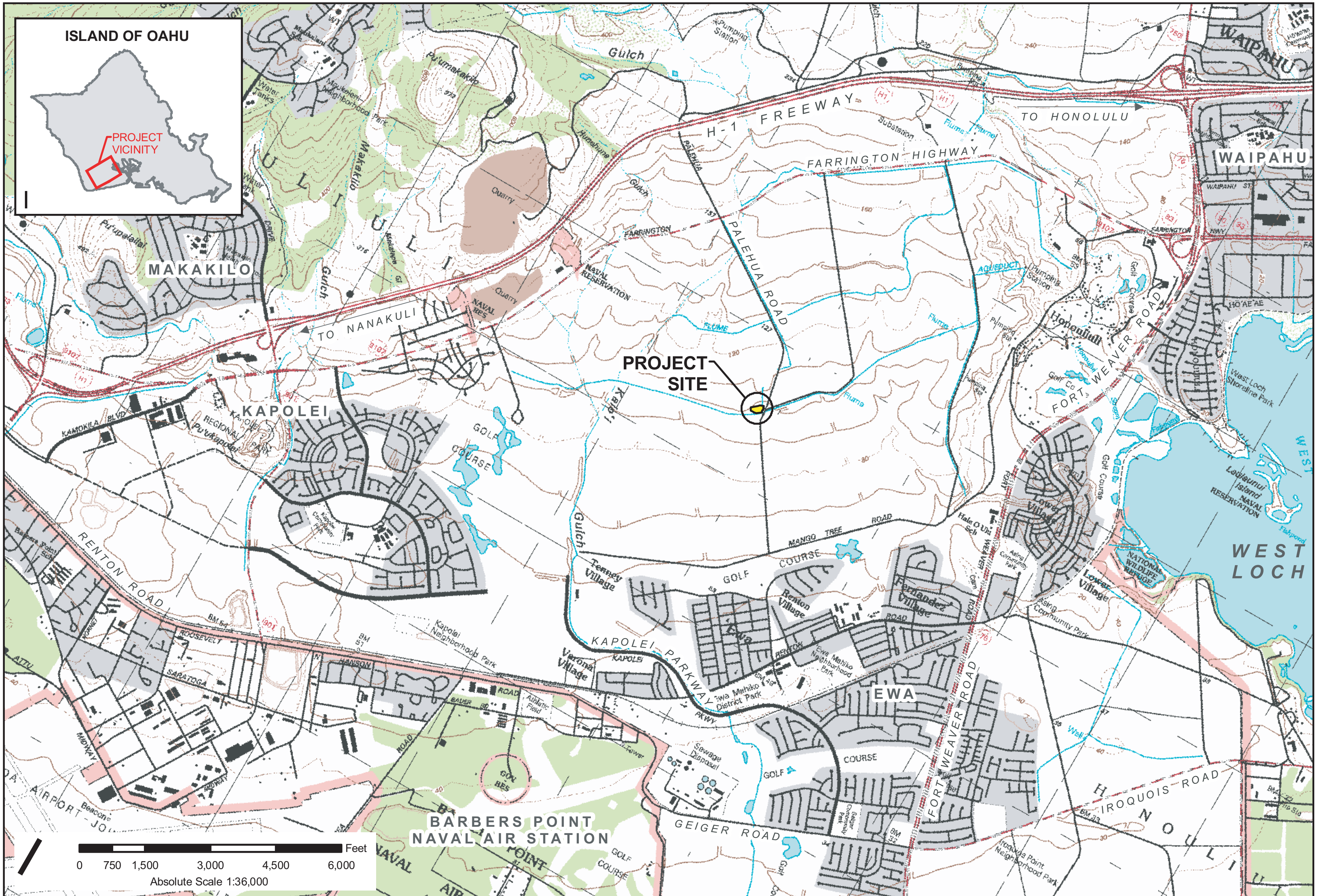

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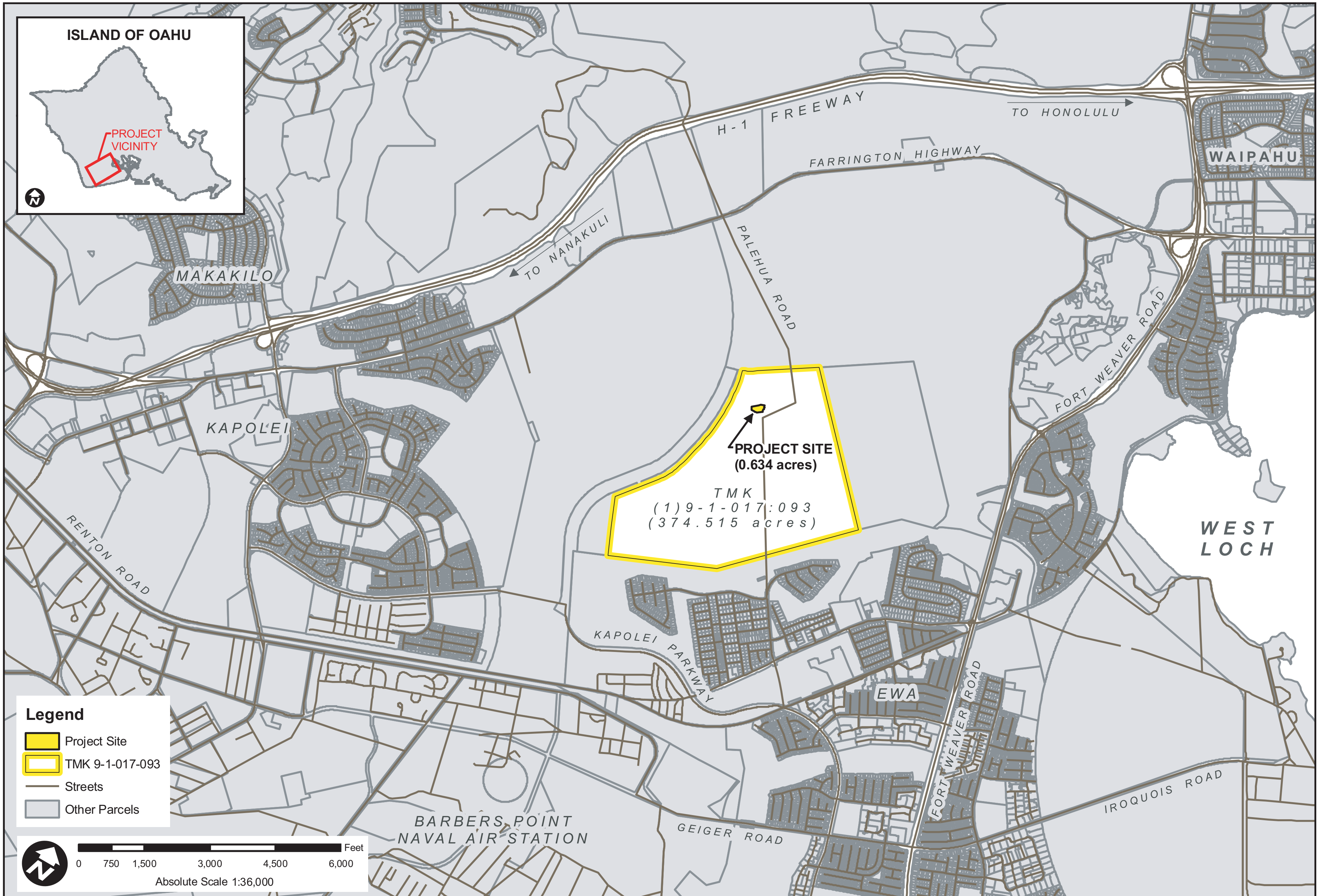
Figure 1 - Location Map
Draft Response Action Memorandum
East Kapolei PML Site
Ewa, Oahu, Hawaii



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May 2010

Figure 2 - Parcel Map
Draft Response Action Memorandum
East Kapolei PML Site
Ewa, Oahu, Hawaii

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ETC Project 09-2012

May 2010

Figure 3 - Project Site Prior to Demolition
Draft Response Action Memorandum
East Kapolei PML Site
Ewa, Oahu, Hawaii

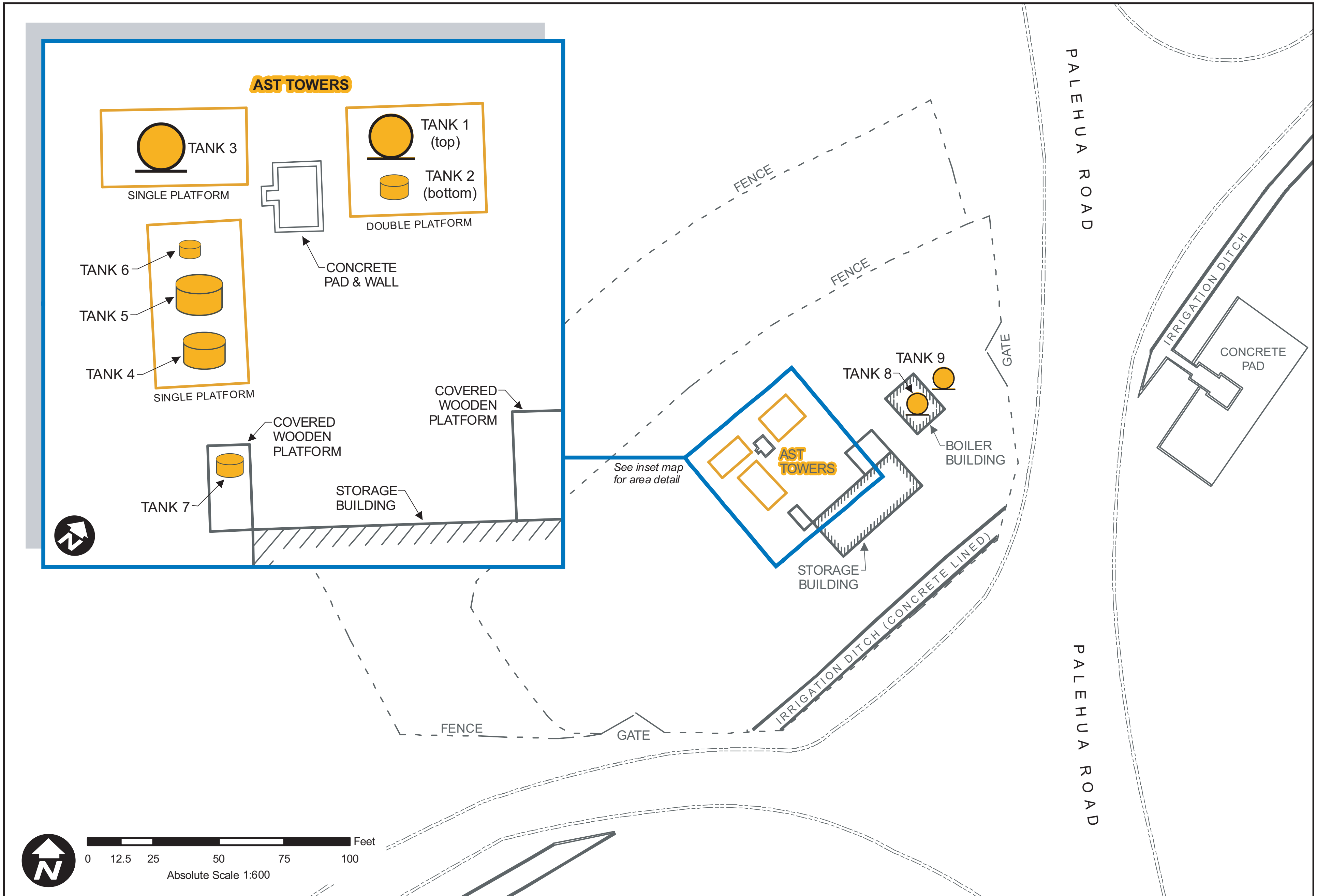

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Figure 4 - AST Locations Prior to Demolition
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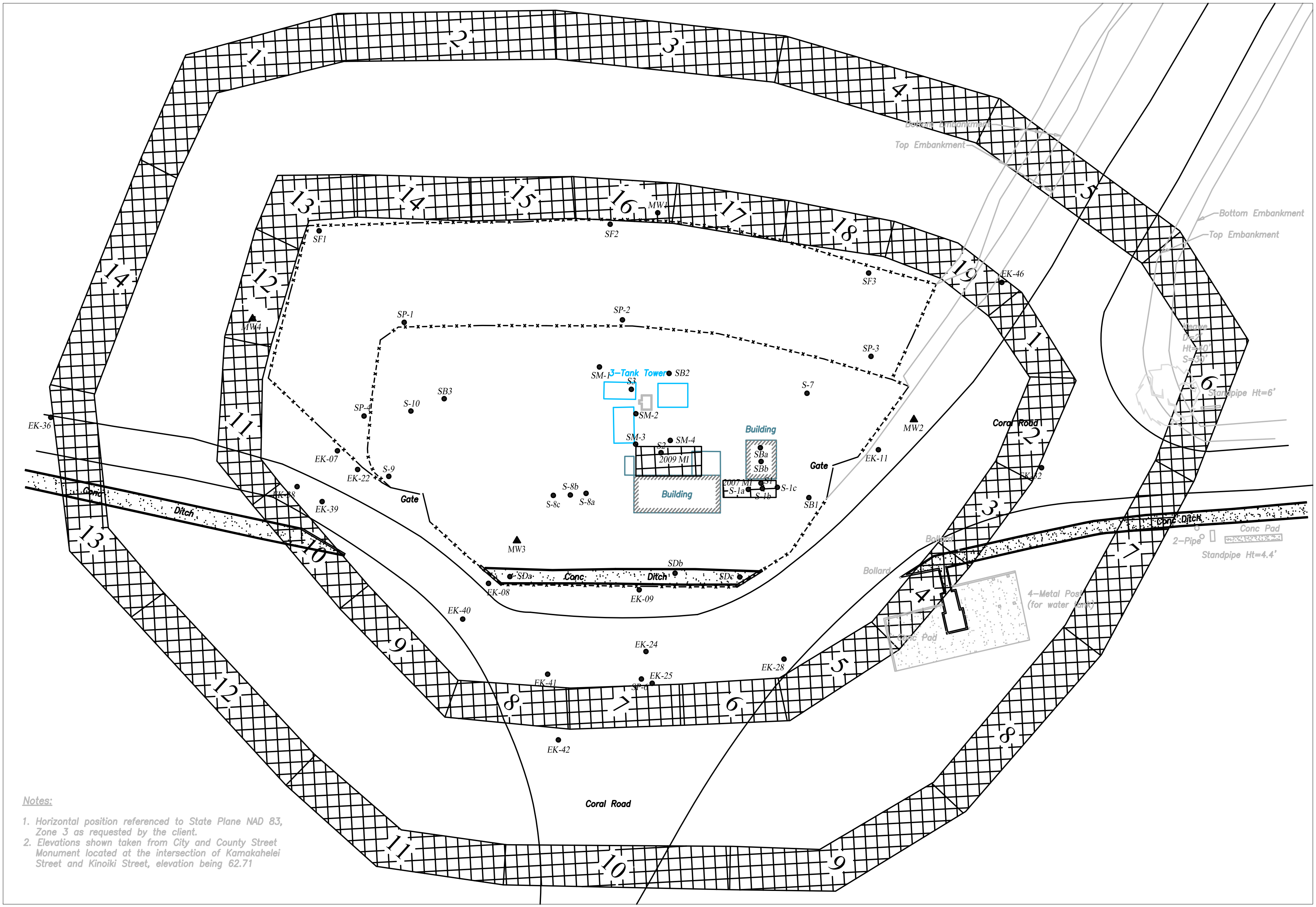
East Kapolei PML Site
Ewa, Oahu, Hawaii



Notes:

1. Horizontal position referenced to State Plane NAD 83, Zone 3 as requested by the client.
2. Elevations shown taken from City and County Street Monument located at the intersection of Kamakahelei Street and Kinoiki Street, elevation being 62.71

30' 0' 30' 60'

Graphical Scale: 1" = 60'
Note: Original Sheet Size is 8.5x11, For All Other Sizes Scale Accordingly

● Discrete sample location

▲ Monitoring well location

Multi-increment sample decision unit, 0-6 inches bgs

EK-24 ● EPA 2009 samples w/ arsenic > 20 mg/kg

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Figure 5 - Historic Sample Locations

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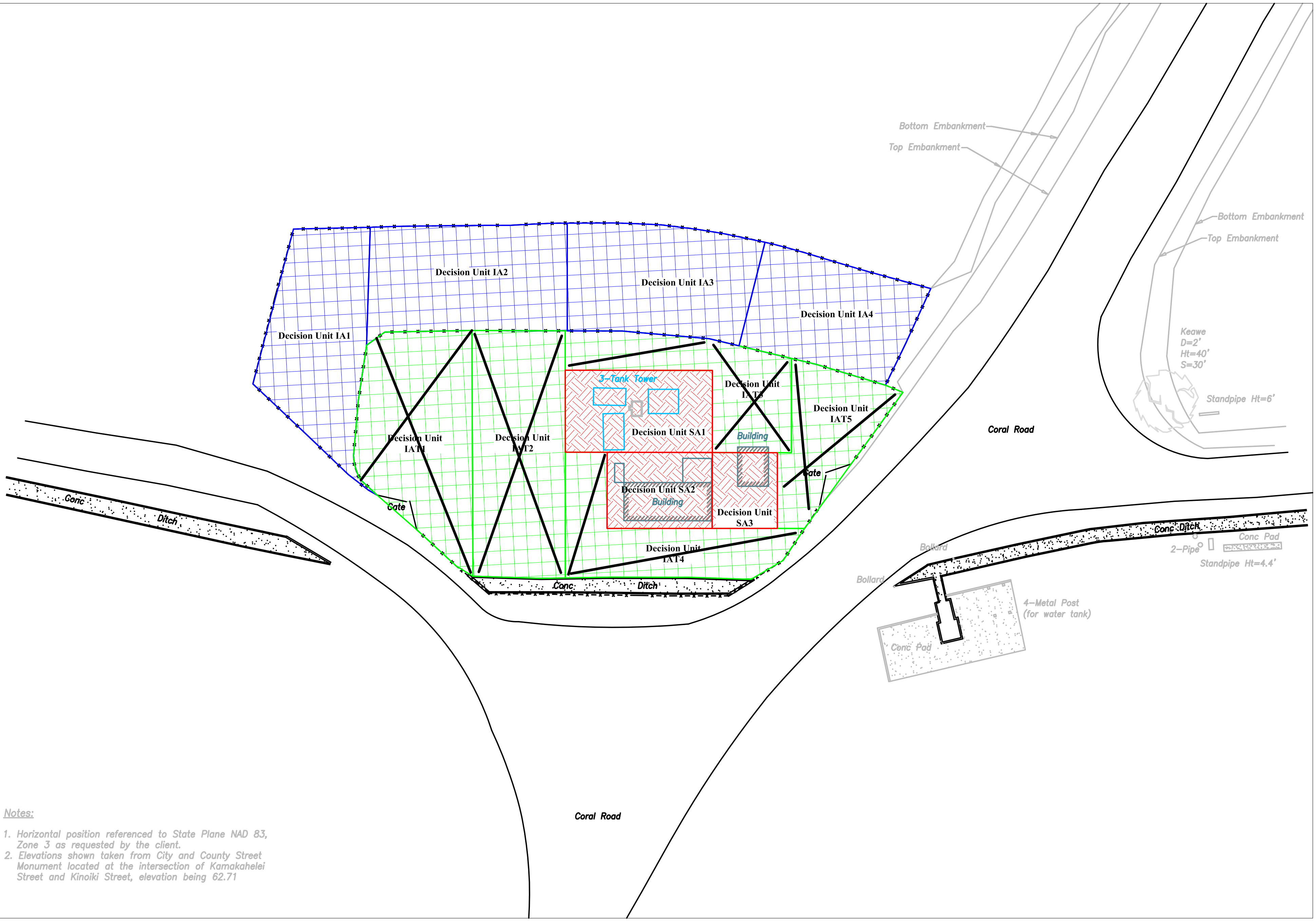
East Kapolei PML Site

Ewa, Oahu, Hawaii



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2. Elevations shown taken from City and County Street Monument located at the intersection of Kamakahelei Street and Kinoiki Street, elevation being 62.71

30' 0' 30' 60'

Graphical Scale: 1" = 60'
Note: Original Sheet Size is 8.5x11, For All Other Sizes Scale Accordingly

Trench locations in IAT1 through IAT5 to depths of 3 feet bgs

Multi-increment sample DUs, 0-6 inches bgs

Multi-increment sample DUs, up to 10 feet bgs

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Figure 6 - Current Sample Locations
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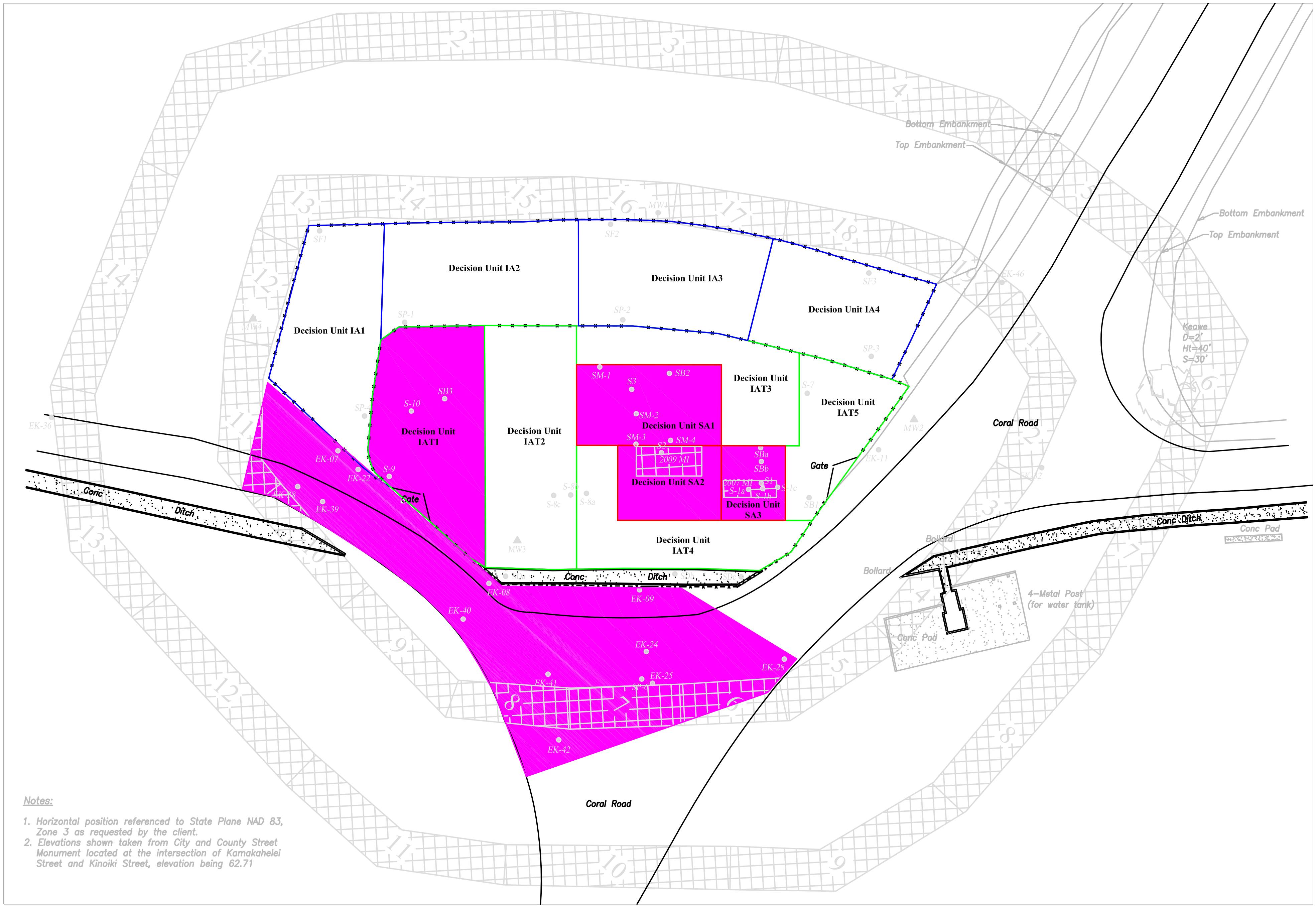
East Kapolei PML Site
Ewa, Oahu, Hawaii



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30' 0' 30' 60'

Graphical Scale: 1" = 60'
Note: Original Sheet Size is 8.5x11, For All Other Sizes Scale Accordingly

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Figure 7 - Extent of Arsenic Impacts
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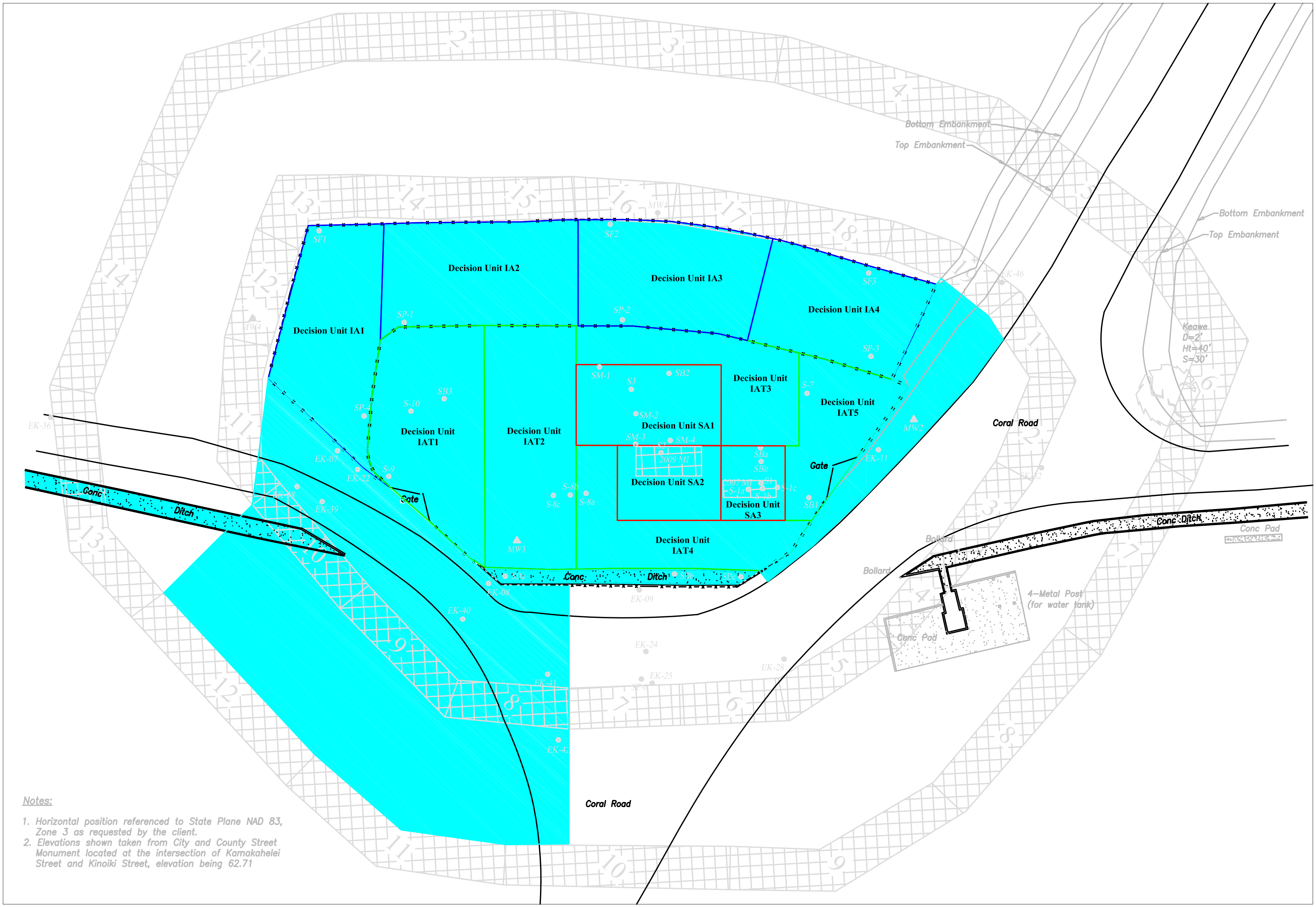
East Kapolei PML Site
Ewa, Oahu, Hawaii



Notes:

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2. Elevations shown taken from City and County Street Monument located at the intersection of Kamakahelei Street and Kinoiki Street, elevation being 62.71

30' 0' 30' 60'

Graphical Scale: 1" = 60'
Note: Original Sheet Size is 8.5x11, For All Other Sizes Scale Accordingly

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Figure 8 - Extent of Dioxin Impacts
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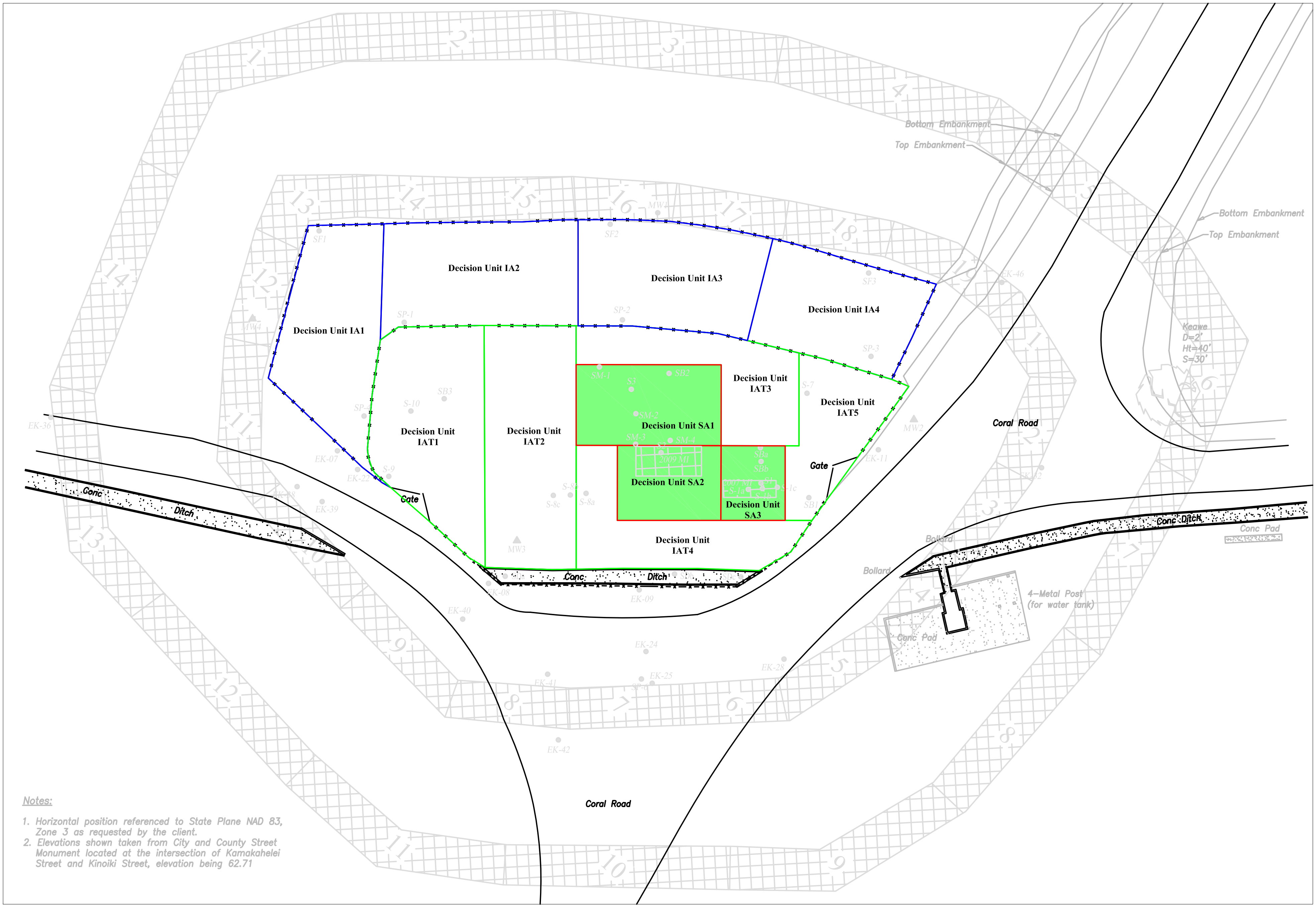
East Kapolei PML Site
Ewa, Oahu, Hawaii



Notes:

1. Horizontal position referenced to State Plane NAD 83, Zone 3 as requested by the client.
2. Elevations shown taken from City and County Street Monument located at the intersection of Kamakahelei Street and Kinoiki Street, elevation being 62.71

30' 0' 30' 60'

Graphical Scale: 1" = 60'
Note: Original Sheet Size is 8.5x11, For All Other Sizes Scale Accordingly

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Figure 9 - Extent of PCP/Triazine Impacts
Draft Response Action Memorandum
East Kapolei PML Site
Ewa, Oahu, Hawaii

Notes:

1. Horizontal position referenced to State Plane NAD 83, Zone 3 as requested by the client.
2. Elevations shown taken from City and County Street Monument located at the intersection of Kamakahelei Street and Kinoiki Street, elevation being 62.71

30' 0' 30' 60'

Graphical Scale: 1" = 60'
Note: Original Sheet Size is 8.5x11, For All Other Sizes Scale Accordingly

Direct exposure hazards associated with dioxins/furans only

Direct exposure hazards associated with arsenic, dioxins/furans, PCP, and/or triazine pesticides

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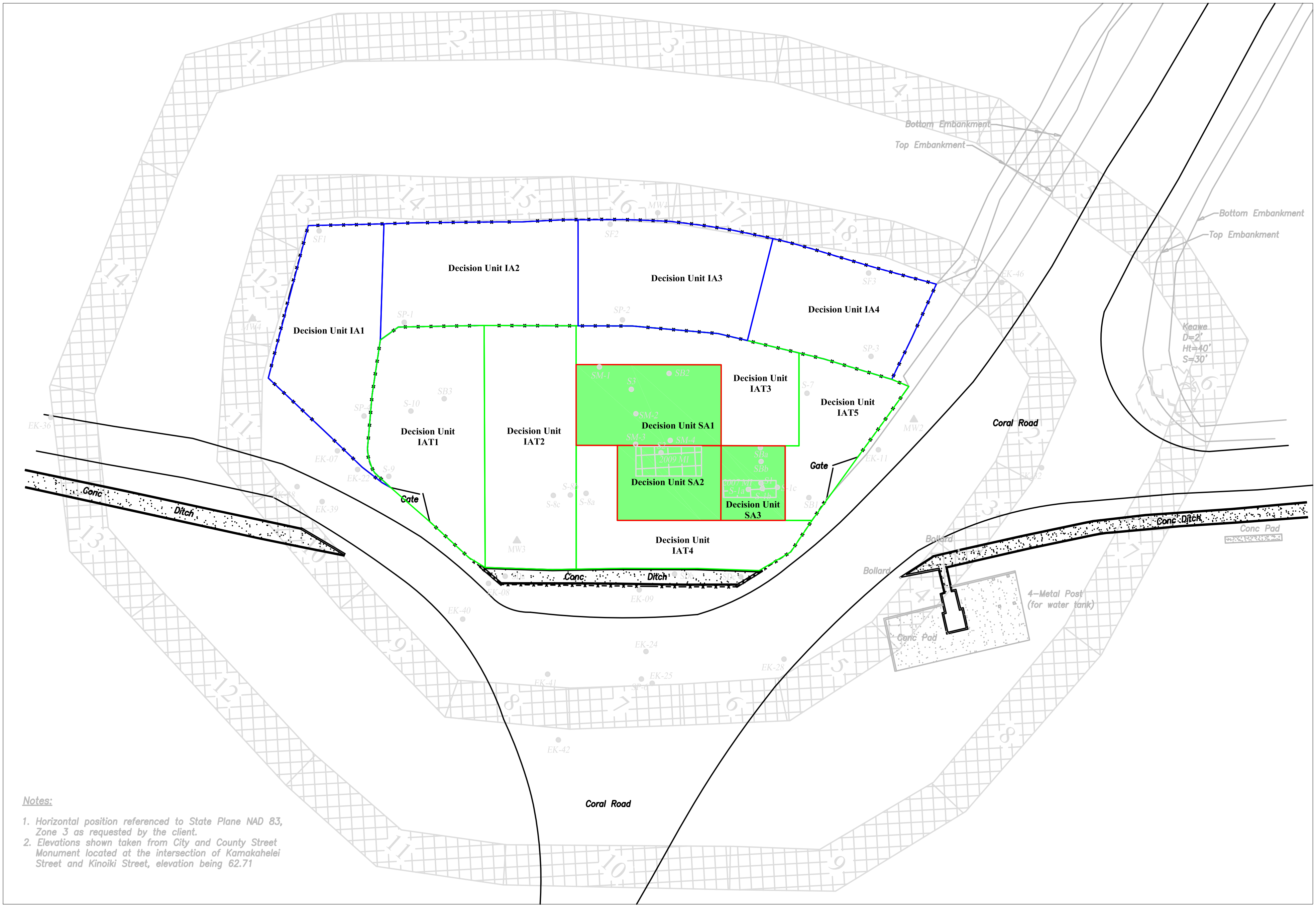
Figure 10 - Direct Exposure Hazards
Draft Response Action Memorandum
East Kapolei PML Site
Ewa, Oahu, Hawaii



Notes:

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Graphical Scale: 1" = 60'
Note: Original Sheet Size is 8.5x11, For All Other Sizes Scale Accordingly

Leaching hazards associated with dioxins/furans, PCP, and/or triazine pesticides

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Figure 11 - Leaching to Groundwater Hazards
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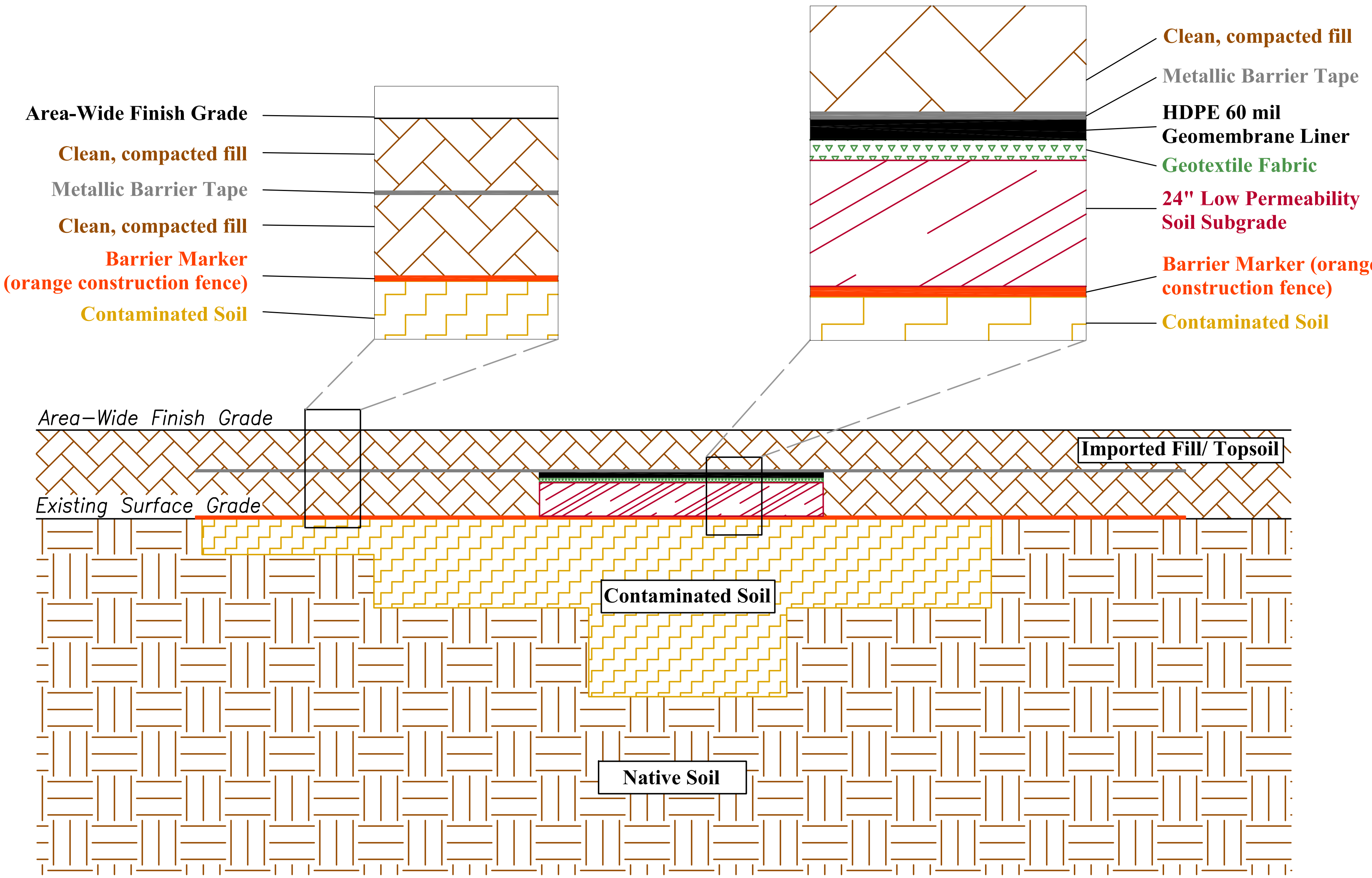
East Kapolei PML Site
Ewa, Oahu, Hawaii



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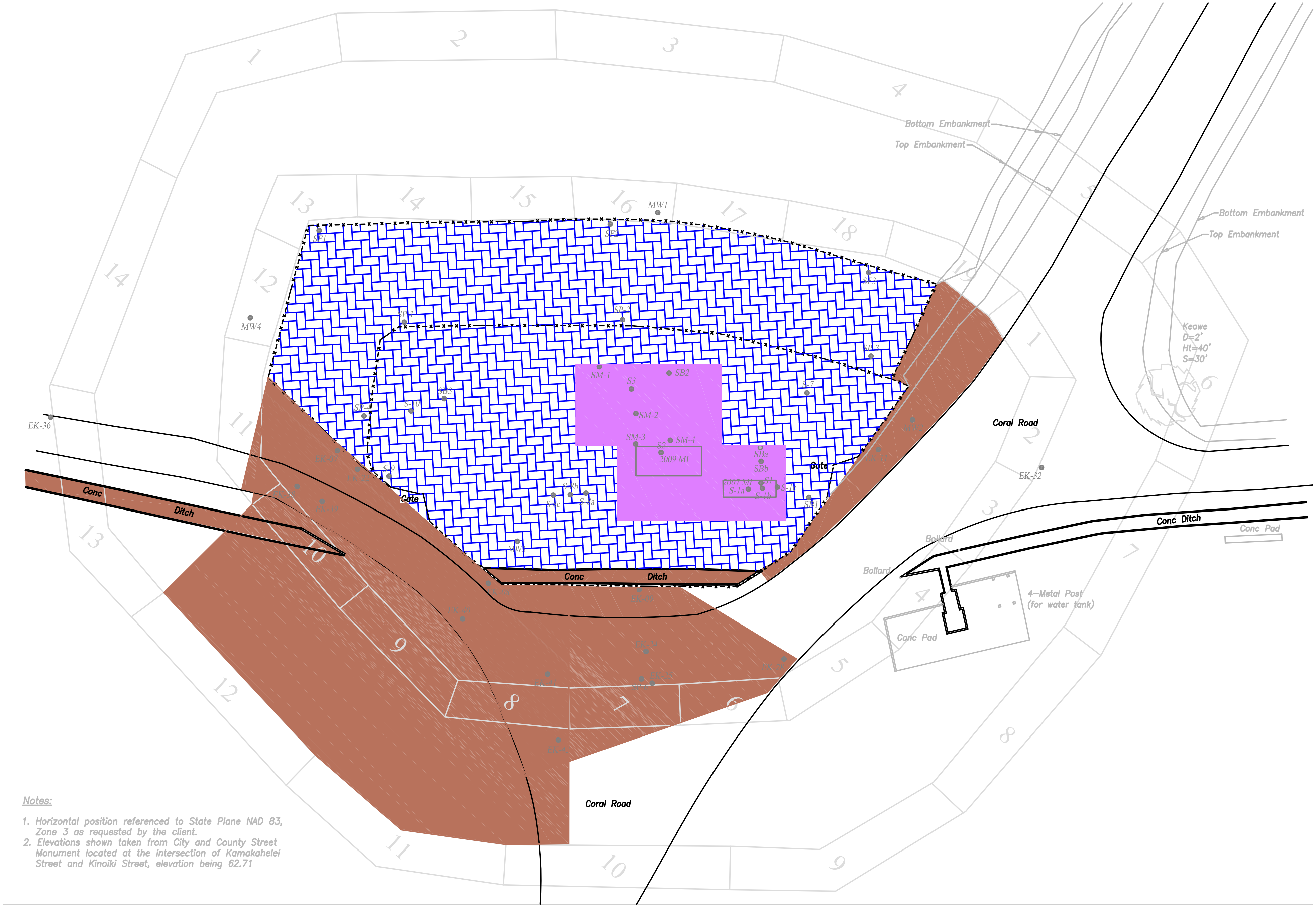
Project 09-2012	**Figure 12 - Conceptual Cross-Section of the Preferred Remedial Alternative** Draft Response Action Memorandum East Kapolei PML Site Ewa, Oahu, Hawaii
Not to Scale	
June 2010	



30' 0' 30' 60'

Graphical Scale: 1" = 60'
Note: Original Sheet Size is 8.5x11, For All Other Sizes Scale Accordingly

(pink)	Conceptual extent of geomembrane liner
(blue hatch)	Conceptual extent of clean, compacted soil cap
(brown)	Extent of off-site soil excavation for relocation onto PML site

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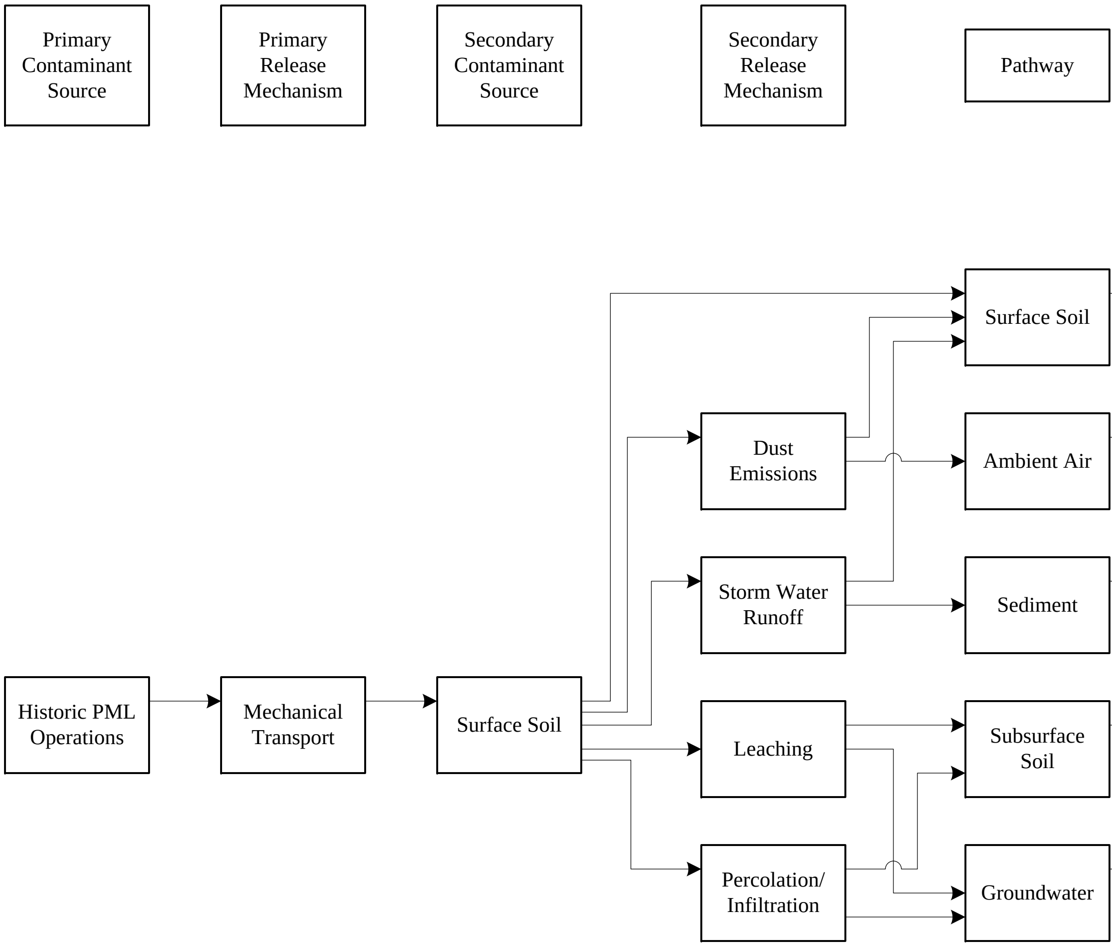
June 2010

Figure 13 - Preferred Alternative, Conceptual Plan View

Draft Response Action Memorandum
East Kapolei PML Site
Ewa, Oahu, Hawaii

APPENDIX I - CONCEPTUAL SITE MODEL DIAGRAM

EAST KAPOLEI PML SITE, CURRENT CONDITIONS



Potential Exposure Routes and Receptors

Pathway	Exposure Route	On-Site Human	Off-Site Human	Site Worker	Aquatic Ecological
Surface Soil	Ingestion	X		X	
	Inhalation	X		X	
	Dermal contact	X		X	
Ambient Air	Ingestion	X	X	X	
	Inhalation	X	X	X	
	Dermal contact	X	X	X	
Sediment	Ingestion		X		X
	Inhalation		X		X
	Dermal contact		X		X
Subsurface Soil	Ingestion			X	
	Inhalation			X	
	Dermal contact			X	
Groundwater	Ingestion		X	X	X
	Inhalation				X
	Dermal contact		X	X	X

APPENDIX I - CONCEPTUAL SITE MODEL DIAGRAM

EAST KAPOLEI PML SITE

SITE CONDITIONS AFTER IMPLEMENTATION OF PREFERRED ALTERNATIVE